DLA-97-P70146

# DECISION SUPPORT TOOLS FOR THE ASSESSMENT OF COMMODITY BID OFFERS MADE TO THE DEFENSE NATIONAL STOCKPILE CENTER

SEPTEMBER 1997

FOR
**DEFENSE LOGISTICS AGENCY
DEFENSE NATIONAL STOCKPILE CENTER
(DNSC)
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*INSIGHT THROUGH ANALYSIS*

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## FOREWORD

This report documents a study of commodity bid offers made to the Defense National Stockpile Center (DNSC). The purpose of the study was to provide DNSC with better information about potential changes in market commodity prices. This report provides the project findings of the new PC based price forecasting model, "market basket" decision support package, and "optimal" price methodology.

We would like to thank Mr. Peter Roman of DNSC-R for his overall guidance and assistance with this project. Additionally, we would like to thank Mr. Tom Rasmussen, Mr. Frank Ringquist, and Mr. Peter Mory for their insights into the commodity markets and guidance during the course of this project. This project would not have been possible without their assistance.

JOHN E. FIRTH
Colonel, USA
Chief, DLA Operations Research Office

**INSIGHT THROUGH ANALYSIS**

# EXECUTIVE SUMMARY

The purpose of this study was to provide additional information to the management of the Defense National Stockpile Center (DNSC) about potential changes in commodity market prices. This report addresses the findings of a commodity market basket analysis, a "optimal" price methodology, and a PC based decision support system.

The market basket analysis of the commodities managed by the DNSC revealed that mathematical correlation exists between many of the commodities. However, the results of the study were inconclusive. This is because of the fact that correlation does not necessarily imply causality. A large positive or negative correlation coefficient does not mean that a change in commodity A automatically causes a change in commodity B. The only conclusion that may be inferred from the correlation coefficient is that a linear trend may exist between commodity A and commodity B.

The "optimal" price analysis focused on Aluminum Oxide Fused Crude. There was insufficient data to calculate the necessary production function for this technique to work. The available data cover a broad time span and does not offer many data points.

While it is disappointing that an "optimal pricing" strategy or a market basket could not be successfully developed, this does not necessarily symbolize a failure. It can be viewed instead as an illustration of the difficulty to provide reliable information of this type. This analysis may be feasible in the future if more data becomes available.

Lastly, the project team was successful in designing an automated PC based price forecasting model designed for use with Microsoft Excel ®. It is intended to complement the existing DNSC-R staff analysis of commodity markets. The program evaluates three different forecasts, Naïve forecast, Double exponential smoothing using Holt's method, and a Variable index dynamic average. It then chooses the forecast with the lowest overall error. Additionally, the program calculates a market momentum over a user specified number of periods and then graphs the output.

There exists significant potential benefits in applying this automated bid evaluation system to leverage increased revenue. Previous analysis of Lead sales for FY 97 demonstrated that this technique could have resulted in a net revenue increase of $1.1 million dollars to the government. This represents a potential 15.8% increase in sales revenue for the period.

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# STUDY DESCRIPTION

## 1.1       <u>PROBLEM STATEMENT</u>

Develop a decision support system that will assist the Defense National Stockpile Center (DNSC) in assessing the suitability of bids on the commodities offered for public sale.

## 1.2       <u>BACKGROUND</u>

On November 19, 1996 at a meeting between DNSC and DLA Operations Research Office (DORO) management, the topic of decision support methodologies to assess the bids received for DNSC commodities was discussed. The DNSC management described the current methodology of assessing bids and wanted a more automated approach for bid evaluation that included alternate forecasting methodologies. The requirement is for a decision support package that will complement the research of the DNSC Marketing office and assist the DNSC decision makers in deciding which bids to award.

## 1.3       <u>OBJECTIVES</u>

**1.3.1** Develop a PC based price forecasting model which will provide an indication of what DNSC commodity prices might be in future international commodity markets.

**1.3.2** Research the potential for developing a "market basket" decision support package which will include all of the commodities sold by the DNSC.

**1.3.3** Explore potential methodologies for estimating the "optimal" price for various commodities.

## 1.4       <u>SCOPE</u>

Overall project functional guidance for this effort was provided by the DNSC Office of Planning & Market Research (DNSC-R), HQ DLA. All operational analysis support was accomplished by the technical support staff assigned by DORO in Richmond, Virginia.

## 1.5     ASSUMPTIONS

There are several underlying assumptions associated with this study. The overall assumptions were: that any computer product that was developed must be uncomplicated for the user, based upon solid analysis and, provide useful information to the user. Additionally, it was assumed that the DNSC-R staff has limited time and resources for collecting additional data and prefers to employ data that is currently available. Specific assumptions are addressed where appropriate.

## 1.6     LITERATURE OVERVIEW

After conducting a review of the forecasting literature it was determined that simple forecasting techniques can often be as effective as complex ones (Winston, 1994), (Nahmias, 1993), (Mahmoud, 1984), (Makridakis et al., 1982). It was not the intent of this study to evaluate every available forecasting technique, but rather to focus on several basic techniques which could yield better information about commodity prices. Thus, research on forecasting techniques for use in this study has focused on both traditional and non-traditional forecasting techniques that met this criteria.

# SECTION 2
# STUDY APPROACH

## 2.1        ANALYTICAL TECHNIQUE

This project is a follow up effort to the consultation work DORO completed in February 1997. The earlier consultation focused on accurately forecasting the market direction for lead prices. This project addressed forecasting the expected market direction for the other commodities that DNSC manages.

An assumption used in this study is that some forecasting methods are better than others, depending upon the characteristics of the time series used for the evaluation (Armstrong, 1984). The forecasting techniques used in this project are considered to be time-series models. This means that each forecast is based upon past data.

It is important to review some fundamental characteristics inherent to predicting future values based on past observations. Forecasting problems are generally classified into three time horizons: short term, intermediate term, and long term. Short term business forecasts are typically measured in days or weeks. Examples of short term forecasts could be predicting daily sales or the number of employees required for shift scheduling. Intermediate term business forecasts are measured in weeks or months and represent the typical planning horizon for DNSC commodity forecasting. Long term business forecasts are usually measured in terms of years and often deal with issues such as long term sales patterns or capacity requirements.

While it is generally acknowledged by management and academia alike that forecasts are usually wrong, it is a fact that managers frequently disregard. The reasons for forecast inaccuracy are as varied as the number of forecasting techniques. This project has attempted to minimize forecast error by comparing multiple forecasting techniques and their associated error. It is assumed that any *viable* forecast must have a mean square error (MSE) or mean absolute deviation (MAD) that is less than the naïve forecast for the period. A naïve forecast is one in which the next period's demand is the same as the current period. The naïve forecast is as follows:

$$F_{t+1} = A_t$$

where: $A_t$ = actual demand at time t

$F_t$ = forecast for time t

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In plain language Naïve forecast looks like this:

Forecast price = Last period price

MAD can be described as the "absolute" sum of the total error divided by the total number of periods. The term absolute refers to changing all of the errors between the forecast and the actual prices into positive values. MSE is similar to MAD except that all of the error values are squared instead of changed into positive values. A characteristic desirable in all forecasts is that they should be unbiased, meaning that the error for each forecast should fluctuate randomly around zero. This can be measured using MAD and MSE with the goal of zero for both values. MAD and MSE are defined as:

$$MAD = \frac{\sum_{t=1}^{n} ABS(A_t - F_t)}{n}$$

$$MSE = \frac{\sum_{t=1}^{n} (A_t - F_t)^2}{n}$$

where:    $A_t$ = actual demand at time t

$F_t$ = forecast for time t

n = number of periods

The forecasts used in this study were developed in the previous consultation. The techniques used for this study were: Naïve forecast, double exponential smoothing (DES) using Holt's method, variable length dynamic index (VIDYA), and Chande momentum oscillator (CMO).

Double exponential smoothing using Holt's method, is a technique that allows for the simultaneous smoothing of the data series and the trend. This method is designed to track time series data with a linear trend. DES requires the specification of two smoothing factors,($\alpha$ ,$\beta$) and uses two equations. One equation is used to estimate the price and one to estimate the trend. A unique feature of this method is that it estimates a new slope for

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the trend in the data with every new forecast. This method can be used for both single period and multiple period forecasts. DES is defined as:

$$S_t = \alpha D_t + (1-\alpha)(S_{t-1}+G_{t-1}),$$
$$G_t = \beta(S_t - S_{t-1}) + (1-\beta)G_{t-1}$$

$$F_t = S_t + G_t$$

where: $S_t$ = value of the intercept at time t

$D_t$ = most current price at time t

$G_t$ = value of the slope at time t

$F_t$ = forecast for time t

$\alpha$ = smoothing constant for the data series

$\beta$ = smoothing constant for the trend

$\alpha \geq \beta$ = for stable forecasts

In plain language terms DSE looks like this:

New Price = Smoothing Factor$_A$ * (Current Price) + (1- Smoothing Factor$_A$) * (Last Price + Last Slope),

New Slope = Smoothing Factor$_B$ * (New Price - Last Price) + (1- Smoothing Factor$_B$) * (Last Slope)

New Forecast = New Price + New Slope

The smoothing factor, ($\alpha$, $\beta$), must be greater than or equal to zero or less than or equal to one for this model to work. The smoothing constant determines the relative weight placed on the current price in determining what the forecasted value must be. The smoothing constant can either be set at an arbitrary value chosen by the user or sometimes an optimal value can be determined. However, as the smoothing factor value increases the relative weight on each current observation increases thus producing a forecast which reacts quickly to changes but has greater variation from period to period.

In this study, regression analysis is used to estimate the initial values for the slope and intercept of the DES equations. Regression analysis is a method that fits a straight line to

a set of data. This technique enables the user to fit a line to the data that will minimize the distance of the initial data points from the line.

The third forecasting technique used in this study is called variable index dynamic average (VIDYA). This technique is a dynamic exponential moving average that adjusts its effective length using market variables and is responsive to market volatility. VIDYA can be indexed to the standard deviation of closing prices, a momentum oscillator, and to the coefficient of determination, $r^2$. The responsiveness and dynamic range of VIDYA will change based on the indexing technique used (Chande & Kroll, 1994). In this study, the standard deviation of closing prices was determined to be the most responsive. To use VIDYA, a volatility index must first be developed. The volatility index is derived from current volatility compared to historical volatility. This is represented as:

$$k = \sigma(\text{x-periods}) / \sigma(\text{reference})$$

where: $k$ = volatility index

$\sigma(\text{x-periods})$ = standard deviation of prices over x-periods

$\sigma(\text{reference})$ = the historical value of standard deviation over x-periods

In plain language the volatility index is:

Index $k$ = standard deviation(x-periods) / standard deviation(reference)

The number of periods is chosen by the user. For example, you could use a 12 month moving average of standard deviation for the reference value. This would then become the historical reference value of standard deviation.

With the volatility index solved the VIDYA equation is expressed as:

$$\text{VIDYA} = \alpha * k * A_t + (1 - \alpha * k) * A_{t-1}$$

where:   $A_t$ = actual demand at time t

$k$ = volatility index

$\alpha$ = smoothing constant for the data series

In plain language VIDYA looks like this:

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VIDYA = alpha * k * Today's closing price + (1-alpha * k) * Yesterday's closing price

The utility of this equation in forecasting prices is found in the addition of the indexing variable. This is substantially different than traditional exponential moving averages which require the index to be constant (Chande & Kroll, 1994).

To augment the forecasting strategies we incorporated methodologies designed to estimate market direction and momentum. The Chande momentum oscillator is a pure momentum oscillator that plots market momentum on a bounded scale of -100 to +100. The market momentum is measured as the difference between the closing prices of different periods. CMO is a variant of the Relative Strength Index (RSI) but differs from it in the following ways. CMO is a direct measurement of market momentum because it uses data for both up and down periods in its numerator. RSI calculations use only the data for up-periods in its market estimates. RSI has a built in smoothing feature which can effect the outcome of calculations. CMO works with unsmoothed data. Once calculated, the values can be smoothed just like any other market indicator. CMO calculations are bound by a -100 to +100 scale which enables the user to quickly assess the magnitude of the market shift. RSI varies from 0 to +100, so the user must use the 50 level for assessing the level of market momentum (Chande & Kroll, 1994).

The CMO is calculated using the sum of the up-period momentum over x periods represented as $S_U$ and $S_D$ is the sum of the down-period momentum over x periods. The CMO numerator is the difference between the sum of the up-period momentum and the sum of the down-period momentum multiplied by 100. The denominator is the absolute sum of the up-period momentum added to the sum of the down-period momentum (Chande & Kroll, 1994). CMO can be represented as:

$$CMO = 100 * (\Sigma_U - \Sigma_D) / |(\Sigma_U + \Sigma_D)|$$

In plain language terms CMO looks like this:

CMO = 100 * (Sum up periods - Sum down periods) / ABS (Sum up periods + Sum down periods)

The usefulness of this indicator is that it can be easily plotted on a bounded scale and provides a consistent measure for comparing market shifts. Another feature of CMO is that it provides both negative and positive values, RSI only has positive values. This feature offers a clearer indication of both the direction and strength of the market momentum.

# SECTION 3
# RESULTS

## 3.1        EXCEL®ADD IN

An add in for Microsoft Excel ® was developed to assist the DNSC-R staff with their
analysis of commodity markets and to automate the forecasting process developed in the
previous consultation. The add in is designed to evaluate a range of prices chosen by the
user and then graph the results. Once the user calls the program from the tools menu,
he/she will be prompted to highlight the range of commodity prices. The user will then
choose the periods for the CMO and how many months of output to be graphed. With
these selections made, the user will then click on "Calculate" and the program will
evaluate the data. The program evaluates Naïve, DES, and VIDYA forecasts for the
period chosen. It then chooses the forecast with the lowest error and graphs the results.
If the Naïve forecast has the lowest error then the program alerts the user that it can not
make a reliable forecast.

It is important to note the effect of the momentum oscillator on the evaluation process.
The user can choose a value between 3 to 18 periods. The greater the number of periods
chosen the more stable the CMO estimate will be. Chande, the technique inventor,
recommends 12 periods in his review of the technique. Consequently, 12 periods were
used during the developmental phase of the study and for the previous consultation. This
seemed to produce stable forecasts with the CMO generally following the movement of
the actual and forecasted prices (see section 3.1.4 CMO Comparison analysis). However,
Chande does specify that the choice is ultimately left to the user to determine the "right"
number of periods for use. The DNSC-R add in is designed to incorporate the CMO
chosen by the user into all calculations. Thus, if the user chooses 3 periods, the program
will evaluate 3 periods worth of standard deviation, 3 periods of up/down momentum etc.

## 3.2        MARKET BASKET ANALYSIS

The commodities used for the market basket analysis and their cash sale values were
provided by DNSC-R staff. The data covered sales for the period January 1995 through
June 1997. With this information we determined an average per unit price for each
commodity by dividing the sale value by the quantity sold. This data was used as the
input for a macro written to determine potential market baskets candidates. The criteria
for inclusion in a market basket was to employ any pair set whose correlation coefficient
is greater than or equal to .5 or less than or equal to -.5. We determined that a positive or
negative correlation of .5 was an indication of commodities potentially moving together.

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A high positive coefficient between two commodities indicates their prices tend to rise and fall at the same time, conversely, a highly negative coefficient indicates that their prices tend to rise and fall in opposite directions. However, correlation does not necessarily imply causality. A large positive or negative correlation coefficient does not mean that a change in commodity A causes a change in commodity B. The only conclusion that may be inferred from the correlation coefficient is that a linear trend *may* exist between commodity A and commodity B. The correlation output matrix is at Appendix A.

## 3.3　　　　　OPTIMAL PRICING ANALYSIS

The optimal pricing analysis focused on Aluminum Oxide Fused Crude. To estimate a demand function for Aluminum Oxide Fused Crude, regression analysis was performed using the quantity sold and cash sale value (Ragsdale, 1995). The acquisition cost (a cumulative number) was estimated using 30 months worth of data provided by DNSC. The information necessary to estimate a production function (e.g., storage costs, labor costs, disposal costs) were unavailable. This made the estimation of an "optimal price" impossible.

The weakest link in both the "market basket" and the "optimal price" strategies is that the historical data that was provided spanned broad time intervals and does not offer many data points for use in forecasting. Consequently, the actual costs of the commodities at any point in time is difficult to estimate given the infrequent market activity for these commodities.

## 3.4　　　　　CMO COMPARISON ANALYSIS

To illustrate the difference between choices in CMO refer to the following charts. All of the graphical output is from the same data set. It's obvious that there is considerable difference between the results. The 3 period CMO is very influenced by changes in the commodity price, while the 18 period CMO is less responsive to changes in prices. It is also interesting to note the differences in the error terms. Both DES and VIDYA have smaller errors than Naïve but are alternatively chosen (see individual error matrix). The technique developed during the previous consultation examining Lead prices was based on a 12 month CMO. The technique incorporated the direction of the CMO indicator, direction of the forecasted price and the direction of the actual price. If all displayed a downward trend then the recommendation was to sell down to the closing price. Which assumes the closing price next month would be even lower. If all were increasing or mixed then sell at the premium price. This assumes the closing price will be higher next month. It does not appear that this same technique will be as useful with other CMO

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selections. Lastly, it is recommended that the user choose a 12 month CMO for evaluations of commodity prices.
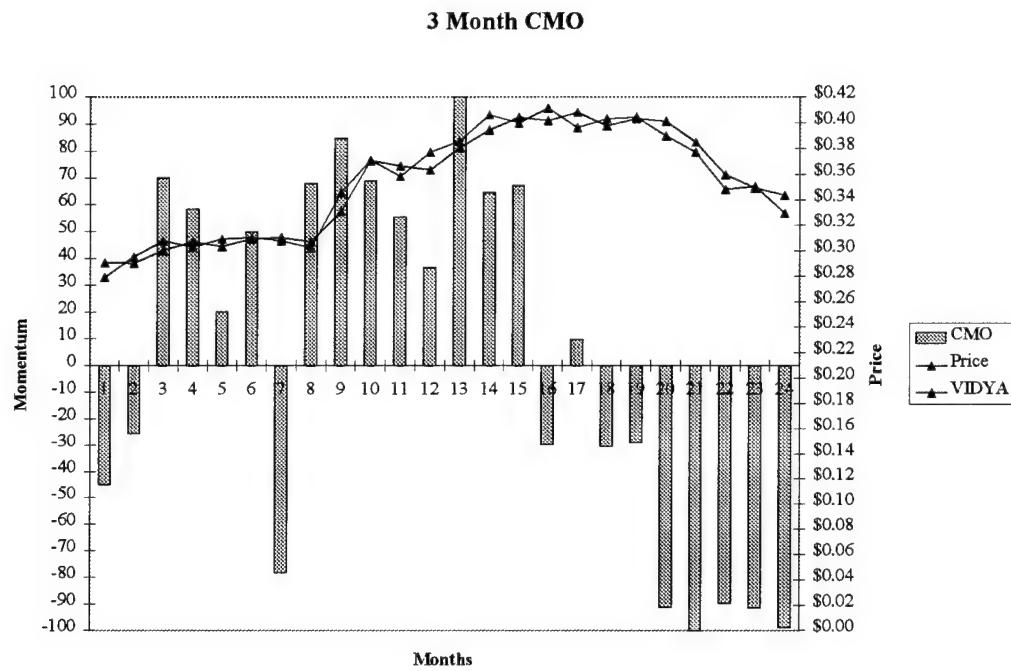
**3 Month CMO**



* The CMO will hit +/- 100 when there are 3 consecutive up or down price periods.

| 3 Month CMO | Error | ALPHA | BETA |
|---|---|---|---|
| VIDYA MSE | 0.0001 | 0.4700 | N/A |
| DES MSE | 0.0002 | 0.5000 | 0.1500 |
| Naive MSE | 0.0005 | | |
| VIDYA MAD | 0.0075 | 0.5000 | N/A |
| DES MAD | 0.0113 | 0.5000 | 0.0500 |
| Naive MAD | 0.0165 | | |

## 12 Month CMO
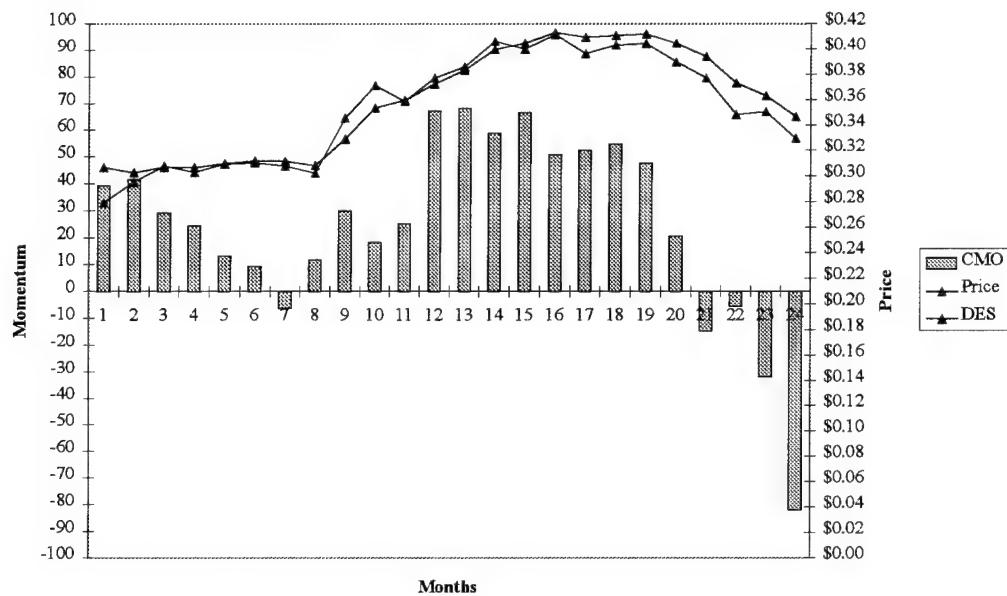


| 12 Month CMO | Error | ALPHA | BETA |
|---|---|---|---|
| DES MSE | 0.0002 | 0.5000 | 0.0500 |
| VIDYA MSE | 0.0002 | 0.5000 | N/A |
| Naive MSE | 0.0005 | | |
| VIDYA MAD | 0.0098 | 0.5000 | N/A |
| DES MAD | 0.0099 | 0.5000 | 0.0500 |
| Naive MAD | 0.0165 | | |

\* DES MSE and VIDYA MSE are the same due to rounding to four decimals. DES MSE is actually .000172 vs. VIDYA MSE at .000175.

## 18 Month CMO
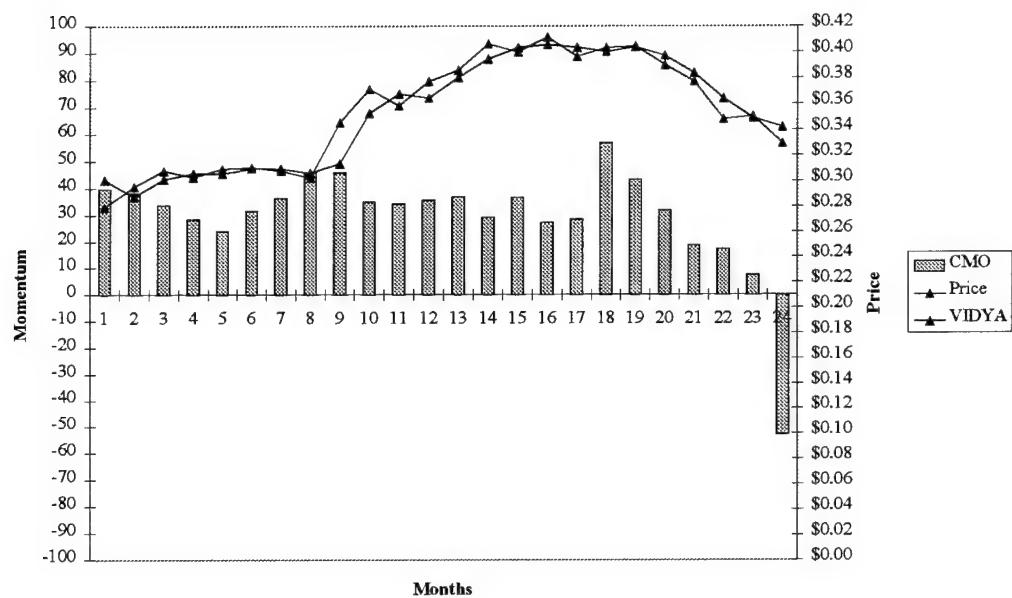


| 18 Month CMO | Error | ALPHA | BETA |
|---|---|---|---|
| VIDYA MSE | 0.0001 | 0.5000 | N/A |
| DES MSE | 0.0002 | 0.5000 | 0.0500 |
| Naive MSE | 0.0005 | | |
| VIDYA MAD | 0.0083 | 0.5000 | N/A |
| DES MAD | 0.0101 | 0.5000 | 0.0500 |
| Naive MAD | 0.0165 | | |

# SECTION 4
## CONCLUSIONS

The use of this automated bid evaluation system represents an opportunity for increased revenue. A previous analysis of Lead sales for FY 97 demonstrated that this technique could have resulted in a net revenue increase of $1,051,722 dollars to the government. This represents a 15.8% increase in sales revenue for the period. These techniques may also be appropriate for the non-terminally traded commodities. Additional testing is required to substantiate the applicability to the non-terminally traded commodities.

Finally, it is disappointing that an "optimal pricing" strategy or a market basket could not be successfully developed with the techniques that were explored under this project. This does not necessarily represent a failure, but rather an illustration of the difficulty to provide reliable information about these infrequently traded commodities. Developing an "optimal pricing" strategy for this set of commodities may be possible in the future if additional historical data becomes available or by possibly exploring other analysis techniques associated with analysis of erratic and a periodic events.

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## Appendix A

The underlined commodities have a correlation coefficient .5 or greater (strong positive relationship) with the commodities listed below them.

### Aluminum

| | |
|---|---|
| Bauxite Metal, Surinam | 0.9995 |
| Chromite, Chemical Grade | 0.6446 |
| Chromium Ferro High Carbon | 0.8389 |
| Columbium, Ferro | 0.818 |
| Germanium Metal | 0.8269 |
| Indium | 0.8288 |
| Kyanite | 0.9995 |
| Manganese Ferro High Carbon | 0.8288 |
| Manganese Ferro Silicon | 0.9995 |
| Mica Muscovite Block | 0.5888 |
| Mica Muscovite Film | 0.5811 |
| Palladium | 0.8288 |
| Platinum | 0.9995 |
| Quinidine | 0.5069 |
| Quinine | 0.5521 |
| Rubber | 0.6661 |
| Tantalum Carbide Powder | 0.9995 |
| Tantalum Oxide | 0.9995 |
| Vanadium | 0.5151 |

### Aluminum Oxide Abrasive Grain

| | |
|---|---|
| Columbium, Ferro | 0.5972 |
| Fluorspar Acid | 0.64 |
| Germanium Metal | 0.5338 |
| Indium | 0.5337 |
| Kyanite | 0.5353 |
| Manganese Electrolytic | 0.5346 |
| Manganese Ferro High Carbon | 0.5337 |
| Manganese Ferro Silicon | 0.5353 |
| Manganese Metal Ore | 0.6887 |
| Palladium | 0.5337 |
| Platinum | 0.5353 |
| Quindine | 0.6708 |
| Quinine | 0.5794 |
| Rubber | 0.6599 |
| Tantalum Carbide Powder | 0.5353 |
| Tantalum Oxide | 0.5353 |

### Aluminum Oxide Fused Crude

| | |
|---|---|
| Bauxite Metal, Surnam | 0.5222 |
| Columbium, Ferro | 0.6324 |
| Fluorspar Acid | 0.6738 |
| Germanium Metal | 0.5752 |
| Indium | 0.5753 |
| Kyanite | 0.5916 |
| Manganese Electrolytic | 0.6276 |
| Manganese Ferro High Carbon | 0.5753 |
| Manganese Ferro Silicon | 0.5916 |
| Mica Muscovite Block | 0.925 |
| Mica Muscovite Film | 0.8542 |
| Mica Muscovite Splittings | 0.666 |
| Palladium | 0.5753 |
| Platinum | 0.5916 |
| Quinidine | 0.8392 |

### Antimony

| | |
|---|---|
| Cadmium | 0.5736 |
| Cobalt | 0.7302 |
| Diamond Stone | 0.5289 |
| Iodine | 0.7646 |
| Nickel | 0.573 |
| Rutile | 0.6469 |
| Vegetable Tannin Quebracho | 0.8399 |

### Bauxite Jamaican

| | |
|---|---|
| Asbestos | 0.6509 |
| Beryllium | 0.7331 |
| Graphite Ceylon Malagasy | 0.6164 |
| Talc | 0.9227 |

### Bauxite Refractory

| | | | |
|---|---|---|---|
| Quinine | 0.5231 | Chromite Metal Ore | 0.8087 |
| Rubber | 0.6733 | Chromite Refractory | 0.7623 |
| Silicon Carbide | 0.6261 | Nickel | 0.6544 |
| Tantalum Carbide Powder | 0.5916 | | |
| Tantalum Oxide | 0.5916 | | |
| Vanadium | 0.7102 | | |
| Vegetable Tannin Chestnut | 0.5355 | | |

**Beryllium**

**Bismuth**

| | | | |
|---|---|---|---|
| Columbium Ferro | 0.6324 | Chromite Metal Ore | 0.5522 |
| Germanium Metal | 0.6447 | Chromite Refractory | 0.5988 |
| Graphite Nat Malagasy | 0.5289 | Cobalt | 0.5563 |
| Indium | 0.6446 | Mica Phlogopite Splittings | 0.6312 |
| Kyanite | 0.5916 | Silicon Carbide | 0.6755 |
| Manganese Ferro High Carbon | 0.6447 | Zinc | 0.6166 |
| Manganese Ferro Silicon | 0.5916 | | |
| Palladium | 0.6447 | **Cadmium** | |
| Platinum | 0.5916 | Diamond Stone | 0.5809 |
| Rubber | 0.7546 | Iodine | 0.8078 |
| Talc | 0.9273 | Manganese Chemical | 0.7451 |
| Tantalum Carbide Powder | 0.5916 | Manganese Dioxide Battery | 0.6832 |
| Tantalum Oxide | 0.5916 | Rutile | 0.7025 |

**Bauxite, Surinam**

**Chromite Chemical Grade**

| | | | |
|---|---|---|---|
| Beryllium | 0.5222 | Chromite Refractory | 0.7233 |
| Chromite Chemical | 0.7098 | Chromium Ferro High Carbon | 0.5912 |
| Chromite Refractory | 0.6302 | Columbium, Ferro | 0.8622 |
| Columbium Ferro | 0.8184 | Germanium Metal | 0.8586 |
| Chromium Ferro High Carbon | 1 | Indium | 0.8585 |
| Diamond Bort | 0.9998 | Kyanite | 0.7118 |
| Germanium Metal | 0.8239 | Manganese Ferro High Carbon | 0.8585 |
| Graphite Nat Malagasy | 0.7779 | Manganese Ferro Silicon | 0.7118 |
| Indium | 0.8257 | Mica Muscovite Film | 0.5002 |
| Kyanite | 1 | Mica Phlogopite Splittings | 0.7072 |
| Manganese Electrolytic | 0.5222 | Palladium | 0.8585 |
| Manganese Ferro High Carbon | 0.8257 | Platinum | 0.7118 |
| Manganese Ferro Silicon | 1 | Quinine | 0.5887 |
| Mica Muscovite Block | 0.6132 | Rubber | 0.6185 |
| Mica Muscovite Film | 0.6257 | Tantalum Carbide Powder | 0.7118 |
| Mica Phlogopite Splittings | 0.518 | Tantalum Oxide | 0.7118 |
| Palladium | 0.8257 | Vegetable Tannin Wattle | 0.5031 |
| Platinum | 1 | | |
| Quindine | 0.5285 | **Chromite Chem Grade** | |
| Quinine | 0.7006 | Chromium Refractory | 0.7233 |

| | |
|---|---|
| Rubber | 0.6596 |
| Talc | 1 |
| Tantalum Carbide Powder | 1 |
| Tantalum Oxide | 1 |
| Vegetable Tannin Wattle | 0.6809 |

| Chromium Ferro High Carbon | |
|---|---|
| Chromium Ferro High Carbon | 0.5912 |
| Columbium, Ferro | 0.8622 |
| Germanium Metal | 0.8586 |
| Indium | 0.8585 |
| Kyanite | 0.7118 |
| Manganese Ferro High Carbon | 0.8585 |
| Manganese Ferro Silicon | 0.7118 |
| Mica Muscovite Film | 0.5002 |
| Palladium | 0.8585 |
| Platinum | 0.7118 |
| Quinine | 0.5887 |
| Rubber | 0.6185 |

**Chromite Ferro Silicon**

| | |
|---|---|
| Graphite Nat Malagasy | 0.699 |
| Chromium Refractory | 0.7163 |
| Cobalt | 0.6683 |
| Diamond Bort | 0.5069 |
| Manganese Metal Ore | 0.5106 |
| Mica Phlogopite Splittings | 0.5897 |
| Nickel | 0.6806 |
| Quartz | 0.7208 |

**Chromite Metal Ore**

| | |
|---|---|
| Manganese Ferro Silicon | 0.626 |
| Mica Phlogopite Splittings | 0.7051 |
| Platinum | 0.626 |
| Sebacic Acid | 0.5063 |
| Tantalum Carbide Powder | 0.626 |
| Tantalum Oxide | 0.626 |

**Chromium Ferro High Carbon**

| | |
|---|---|
| Columbium, Ferro | 0.8184 |
| Germanium Metal | 0.8273 |
| Graphite Nat Malagasy | 0.5204 |
| Indium | 0.8292 |
| Kyanite | 1 |
| Manganese Ferro High Carbon | 0.8292 |
| Manganese Ferro Silicon | 1 |
| Mica Muscovite Block | 0.5214 |
| Mica Muscovite Film | 0.5765 |
| Palladium | 0.8291 |
| Platinum | 1 |
| Quinine | 0.6355 |
| Rubber | 0.6672 |
| Talc | 0.6198 |
| Tantalum Carbide Powder | 1 |
| Tantalum Oxide | 1 |
| Vanadium | 0.5162 |

**Columbium, Ferro**

| | |
|---|---|
| Diamond Bort | 0.8183 |
| Fluorspar Acid | 0.588 |
| Germanium Metal | 0.9995 |
| Graphite Nat Malagasy | 0.8907 |
| Indium | 0.9999 |
| Kyanite | 0.8141 |
| Manganese Electrolytic | 0.6324 |
| Manganese Ferro High Carbon | 0.9999 |
| Manganese Ferro Silicon | 0.8141 |
| Mica Muscovite Block | 0.6879 |
| Mica Muscovite Film | 0.7543 |
| Mica Phlogopite Splittings | 0.5181 |
| Palladium | 0.9999 |
| Platinum | 0.8141 |
| Quinidine | 0.64 |
| Quinine | 0.8485 |
| Rubber | 0.8294 |
| Tin | 0.5245 |
| Talc | 0.8184 |
| Tantalum Carbide Powder | 0.8141 |
| Tantalum Oxide | 0.8141 |
| Vanadium | 0.5813 |
| Vegetable Tannin Wattle | 0.8396 |

**Cobalt**

| | |
|---|---|
| Mica Phlogopite Splittings | 0.5829 |

| | | | |
|---|---|---|---|
| Nickel | 0.5136 | | |
| Vegetable Tannin Quebracho | 0.7481 | **Fluorspar Metal** | |
| | | Manganese Chemical | 0.5603 |
| | | Manganese Dioxide Battery | 0.6605 |
| **Diamond Stone** | | Mica Muscovite Film | 0.5501 |
| Iodine | 0.6993 | Mica Phlogopite Splittings | 0.5329 |
| Manganese Chemical | 0.7567 | Quinine | 0.6659 |
| Manganese Dioxide Battery | 0.6314 | Rubber | 0.554 |
| Rutile | 0.7874 | Sebacic Acid | 0.6188 |
| Sebacic Acid | 0.7464 | Vegetable Tannin Quebracho | 0.6008 |
| Vegetable Tannin Quebracho | 0.5142 | | |
| | | **Graphite Ceylon Malagasy** | |
| | | Rutile | 0.5641 |
| | | Sebacic Acid | 0.5249 |
| | | Talc | 0.5013 |
| | | | |
| **Diamond Bort** | | **Fluorspar Acid** | |
| Germanium Metal | 0.6842 | Germanium Metal | 0.602 |
| Graphite Nat Malagasy | 0.5447 | Indium | 0.6019 |
| Indium | 0.829 | Kyanite | 0.5487 |
| Kyanite | 0.9998 | Manganese Electrolytic | 0.6851 |
| Manganese Electrolytic | 0.5781 | Manganese Ferro High Carbon | 0.6019 |
| Manganese Electrolytic | 0.5781 | Manganese Ferro Silicon | 0.5487 |
| Manganese Ferro High Carbon | 0.829 | Mica Muscovite Block | 0.746 |
| Manganese Ferro Silicon | 0.9998 | Mica Muscovite Film | 0.7611 |
| Palladium | 0.829 | Palladium | 0.6019 |
| Platinum | 0.9998 | Platinum | 0.5487 |
| Quartz | 0.5281 | Quinidine | 0.7858 |
| Quinine | 0.5142 | Quinine | 0.7111 |
| Rubber | 0.6666 | Rubber | 0.7278 |
| Tantalum Carbide Powder | 0.9998 | Silicon Carbide | 0.5471 |
| Tantalum Oxide | 0.9998 | Tantalum Carbide Powder | 0.5487 |
| Vegetable Tannin Chestnut | 0.5518 | Tantalum Oxide | 0.5487 |
| Vegetable Tannin Wattle | 0.6343 | Vanadium | 0.6135 |
| | | Vegetable Tannin Chestnut | 0.5222 |
| **Germanium Metal** | | Vegetable Tannin Wattle | 0.5861 |
| Graphite Nat Malagasy | 0.8941 | | |
| Indium | 0.9999 | **Graphite Nat Malagasy** | |
| Kyanite | 0.8197 | Indium | 0.8946 |
| Manganese Electrolytic | 0.5641 | Kyanite | 0.7732 |
| Manganese Ferro High Carbon | 0.9999 | Manganese Ferro High Carbon | 0.8946 |
| Manganese Ferro Silicon | 0.8197 | Manganese Ferro Silicon | 0.7732 |
| Mica Muscovite Block | 0.6476 | Palladium | 0.8946 |
| Mica Muscovite Film | 0.7279 | Platinum | 0.7732 |

Mica Phlogopite Splittings — 0.5096
Palladium — 0.9999
Platinum — 0.8197
Quinidine — 0.5736
Quinine — 0.8528
Rubber — 0.8339
Talc — 0.8273
Tantalum Carbide Powder — 0.8197
Tantalum Oxide — 0.8197
Tin — 0.5043
Vanadium — 0.5813
Vegetable Tannin Wattle — 0.834

Rubber — 0.705
Sebacic Acid — 0.5065
Talc — 0.5349
Tantalum Carbide Powder — 0.7732
Tantalum Oxide — 0.7732

**Iodine**

| Material | Value |
| --- | --- |
| Manganese Chemical | 0.6317 |
| Manganese Dioxide Battery | 0.5175 |
| Nickel | 0.5554 |
| Rutile | 0.9165 |
| Vegetable Tannin Quebracho | 0.5137 |

**Manganese Chemical**

| Material | Value |
| --- | --- |
| Manganese Dioxide Battery | 0.734 |
| Rutile | 0.7146 |

**Manganese Dioxide Battery**

| Material | Value |
| --- | --- |
| Rutile | 0.6279 |
| Sebacic Acid | 0.5925 |
| Vanadium | 0.5614 |

**Indium**

| Material | Value |
| --- | --- |
| Kyanite | 0.8216 |
| Manganese Electrolytic | 0.5641 |
| Manganese Ferro High Carbon | 1 |
| Manganese Ferro Silicon | 0.8216 |
| Mica Muscovite Block | 0.648 |
| Mica Muscovite Film | 0.7279 |
| Mica Phlogopite Splittings | 0.5104 |
| Palladium | 1 |
| Platinum | 0.8216 |
| Quinidine | 0.5736 |
| Quinine | 0.8528 |
| Rubber | 0.8338 |
| Talc | 0.8292 |
| Tantalum Carbide Powder | 0.8216 |
| Tantalum Oxide | 0.8216 |
| Tin | 0.5042 |
| Vanadium | 0.581 |
| Vegetable Tannin Wattle | 0.8439 |

**Kyanite**

| Material | Value |
| --- | --- |
| Manganese Electrolytic | 0.5916 |
| Manganese Ferro High Carbon | 0.8216 |
| Manganese Ferro Silicon | 1 |
| Mica Muscovite Block | 0.6525 |
| Mica Muscovite Film | 0.6488 |
| Mica Phlogopite Splittings | 0.6541 |
| Palladium | 0.8216 |
| Platinum | 1 |
| Quinidine | 0.5954 |
| Quinine | 0.6928 |
| Rubber | 0.6504 |
| Talc | 1 |
| Tantalum Carbide Powder | 1 |
| Tantalum Oxide | 1 |
| Tin | 0.5126 |
| Vanadium | 0.5291 |
| Vegetable Tannin Wattle | 0.6724 |

**Manganese Electroylic**

| Material | Value |
| --- | --- |
| Manganese Ferro High Carbon | 0.5641 |
| Manganese Ferro Silicon | 0.5916 |
| Mica Muscovite Block | 0.6205 |

**Manganese Ferro High Carbon**

| Material | Value |
| --- | --- |
| Manganese Ferro Silicon | 0.8216 |
| Mica Muscovite Block | 0.648 |
| Mica Muscovite Film | 0.7279 |

| | | | |
|---|---|---|---|
| Mica Muscovite Film | 0.6591 | Mica Phlogopite Splittings | 0.5103 |
| Mica Muscovite Splitting | 0.5479 | Palladium | 1 |
| Palladium | 0.5641 | Platinum | 0.8216 |
| Platinum | 0.5916 | Quindine | 0.5736 |
| Quindine | 0.7982 | Quinine | 0.8528 |
| Quinine | 0.6299 | Rubber | 0.8338 |
| Rubber | 0.6602 | Talc | 0.8292 |
| Silicon Carbide | 0.743 | Tantalum Carbide Powder | 0.8216 |
| Tantalum Carbide Powder | 0.5916 | Tantalum Oxide | 0.8216 |
| Tantalum Oxide | 0.5916 | Tin | 0.5042 |
| Vegetable Tannin Chestnut | 0.7632 | Vanadium | 0.581 |
| Vegetable Tannin Wattle | 0.6786 | Vegetable Tannin Wattle | 0.8439 |
| Zinc | 0.5426 | | |

**Manganese Metal Ore Grade**

**Mica Muscovite Splittings**

| | | | |
|---|---|---|---|
| Quartz | 0.8041 | Vegetable Tannin Chestnut | 0.5991 |

**Mica Phlogopite Splittings**

**Nickel**

| | | | |
|---|---|---|---|
| Palladium | 0.5104 | Rutile | 0.5364 |
| Platinum | 0.6541 | | |
| Tantalum Carbide Powder | 0.6541 | | |
| Tantalum Oxide | 0.6541 | | |
| Vegetable Tannin Quebracho | 0.6866 | | |

**Manganese Ferro Silicon**

**Mica  Muscovite Block**

| | | | |
|---|---|---|---|
| Mica Muscovite Block | 0.6525 | Mica Muscovite Film | 0.9296 |
| Mica Muscovite Film | 0.6488 | Mica Muscovite Splittings | 0.5137 |
| Mica Phlogopite Splittings | 0.6541 | Palladium | 0.648 |
| Palladium | 0.8216 | Platinum | 0.6525 |
| Platinum | 1 | Quinidine | 0.9113 |
| Quinidine | 0.5954 | Quinine | 0.5869 |
| Quinine | 0.6928 | Rubber | 0.7179 |
| Rubber | 0.6504 | Silicon Carbide | 0.5677 |
| Talc | 1 | Silver | 0.5333 |
| Tantalum Carbide Powder | 1 | Tantalum Carbide Powder | 0.6525 |
| Tantalum Oxide | 1 | Tantalum Oxide | 0.6525 |
| Tin | 0.5126 | Vanadium | 0.8107 |
| Vanadium | 0.5291 | Vegetable Tannin Chestnut | 0.5603 |
| Vegetable Tannin Wattle | 0.6724 | | |

**Platinum**

**Mica Muscovite Film**

| | | | |
|---|---|---|---|
| | | Quinidine | 0.5954 |
| Palladium | 0.7279 | Quinine | 0.6928 |
| Platinum | 0.6488 | Rubber | 0.6504 |
| Quinidine | 0.8305 | Talc | 1 |

| | | | |
|---|---|---|---|
| Quinine | 0.7105 | **Tantalum Carbide Powder** | 1 |
| Rubber | 0.7624 | Tantalum Oxide | 1 |
| Silicon Carbide | 0.6208 | Tin | 0.5126 |
| Silver | 0.5729 | Vanadium | 0.5291 |
| Tantalum Carbide Powder | 0.6488 | Vegetable Tannin Wattle | 0.6724 |
| Tantalum Oxide | 0.6488 | | |
| Vanadium | 0.8141 | **Quinidine** | |
| Vegetable Tannin Chestnut | 0.6125 | Quinine | 0.5318 |
| Vegetable Tannin Wattle | 0.5687 | Rubber | 0.6714 |
| Zinc | 0.5713 | Silicon Carbide | 0.5857 |
| | | Silver | 0.7194 |
| **Palladium** | | Tantalum Carbide Powder | 0.5954 |
| Platinum | 0.8216 | Tantalum Oxide | 0.5954 |
| Quinidine | 0.5736 | Vanadium | 0.8309 |
| Quinine | 0.8528 | Vegetable Tannin Chestnut | 0.6138 |
| Rubber | 0.8338 | | |
| Talc | 0.8292 | **Rutile** | |
| Tantalum Carbide Powder | 0.8216 | Sebacic Acid | 0.5459 |
| Tantalum Oxide | 0.8216 | | |
| Tin | 0.5042 | **Silicon Carbide** | |
| Vanadium | 0.581 | Vegetable Tannin Chestnut | 0.7044 |
| Vegetable Tannin Wattle | 0.8439 | Vegetable Tannin Wattle | 0.5023 |
| | | Zinc | 0.771 |
| **Quinine** | | | |
| Rubber | 0.9982 | **Silver** | |
| Tantalum Carbide Powder | 0.6928 | Vanadium | 0.7058 |
| Tantalum Oxide | 0.6928 | | |
| Vegetable Tannin Chestnut | 0.5056 | | |
| Vegetable Tannin Wattle | 0.8724 | | |
| | | | |
| **Rubber** | | **Talc** | |
| Silver | 0.5332 | Tantalum Carbide Powder | 1 |
| Talc | 0.6672 | Tantalum Oxide | 1 |
| Tantalum Carbide Powder | 0.6504 | | |
| Tantalum Oxideq | 0.6504 | **Vegetable Tannin Chestnut** | |
| Tin | 0.6891 | Vegetable Tannin Wattle | 0.6414 |
| Vanadium | 0.6801 | Zinc | 0.5497 |
| Vegetable Tannin Chestnut | 0.5 | | |
| Vegetable Tannin Wattle | 0.9993 | | |
| | | | |
| **Tantalum Carbide Powder** | | | |
| Tantalum Oxide | 1 | | |
| Tin | 0.5126 | | |
| Vanadium | 0.5291 | | |
| Vegetable Tannin Wattle | 0.6724 | | |

The underlined commodities have a correlation coefficient -.5 or less (strong negative relationship) with the commodities listed below them.

**Antimony**
| | |
|---|---|
| Aluminum Oxide Abrasive Grain | -0.801 |

**Cadmium**
| | |
|---|---|
| Aluminum Oxide Abrasive Grain | -0.847 |

**Diamond Stones**
| | |
|---|---|
| Aluminum Oxide Abrasive Grain | -0.707 |

**Germanium Metal**
| | |
|---|---|
| Cadmium | -0.528 |

**Indium**
| | |
|---|---|
| Cadmium | -0.528 |

**Iodine**
| | |
|---|---|
| Aluminum Oxide Abrasive Grain | -0.979 |
| Fluorspar Acid | -0.689 |
| Germanium Metal | -0.564 |
| Indium | -0.564 |

**Kyanite**
| | |
|---|---|
| Antimony | -0.563 |
| Cadmium | -0.529 |
| Cobalt | -0.697 |
| Iodine | -0.592 |

**Lead**
| | |
|---|---|
| Bauxite Refractory | -0.605 |

**Manganese Chemical**
| | |
|---|---|
| Aluminum Oxide Abrasive Grain | -0.66 |

**Manganese Dioxide Battery**
| | |
|---|---|
| Aluminum Oxide Abrasive Grain | -0.553 |

**Manganese Electrolytic**
| | |
|---|---|
| Iodine | -0.607 |

**Manganese Ferro Silicon**
| | |
|---|---|
| Antimony | -0.563 |
| Cadmium | -0.529 |
| Cobalt | -0.697 |
| Iodine | -0.592 |

**Manganese Metal Ore**
| | |
|---|---|
| Cadmium | -0.858 |
| Diamond Stones | -0.528 |
| Iodine | -0.66 |
| Manganese Chemical | -0.746 |
| Manganese Dioxide Battery | -0.656 |

**Mica Muscovite Splittings**
| | |
|---|---|
| Manganvese Ferro Silicon | -0.566 |
| Kyanite | -0.566 |

**Nickel**
| | |
|---|---|
| Aluminum Oxide Fused Crude | -0.525 |
| Kyanite | -0.521 |
| Lead | -0.532 |
| Manganese Ferro Silicon | -0.521 |
| Mica Muscovite Block | -0.676 |

**Palladium**
| | |
|---|---|
| Cadmium | -0.528 |
| Iodine | -0.564 |

**Platinum**
| | |
|---|---|
| Antimony | -0.563 |
| Cadmium | -0.529 |
| Cobalt | -0.697 |
| Iodine | -0.592 |
| Mica Muscovite Splittings | -0.566 |
| Nickel | -0.521 |

**Quartz**
| | |
|---|---|
| Cadmium | -0.74 |
| Manganese Chemical | -0.616 |

**Manganese Ferro High Carbon**

| | |
|---|---|
| Cadmium | -0.528 |
| Iodine | -0.564 |

**Quinine**

| | |
|---|---|
| Iodine | -0.568 |

**Quinidine**

| | |
|---|---|
| Antimony | -0.697 |
| Chromite Metal Ore | -0.614 |
| Iodine | -0.713 |
| Nickel | -0.787 |

**Rubber**

| | |
|---|---|
| Antimony | -0.534 |
| Cadmium | -0.6 |
| Iodine | -0.66 |
| Nickel | -0.544 |

**Rutile**

| | |
|---|---|
| Aluminum Oxide Abrasive Grain | -0.89 |
| Fluorspar Acid | -0.612 |
| Kyanite | -0.507 |
| Platinum | -0.507 |
| Quinidine | -0.632 |
| Quinine | -0.51 |
| Manganese Ferro Silicon | -0.507 |
| Manganese Metal Ore | -0.626 |
| Rubber | -0.576 |

**Sliver**

| | |
|---|---|
| Bauxite Refractory | -0.633 |
| Chromite Metal Ore | -0.676 |
| Nickel | -0.835 |

| | |
|---|---|
| Manganese Dioxide Battery | -0.513 |

**Tantalum Oxide**

| | |
|---|---|
| Antimony | -0.563 |
| Cadmium | -0.529 |
| Cobalt | -0.697 |
| Iodine | -0.592 |
| Mica Muscovite Splittings | -0.566 |
| Nickel | -0.521 |
| Rutile | -0.507 |

**Vanadium**

| | |
|---|---|
| Chromite Metal Ore | -0.53 |
| Nickel | -0.715 |

**Vegetable Tannin Quebracho**

| | |
|---|---|
| Aluminum Oxide Abrasive Grain | -0.571 |
| Kyanite | -0.573 |
| Manganese Ferro Silicon | -0.573 |
| Platinum | -0.573 |
| Tantalum Carbide Powder | -0.573 |
| Tantalum Oxide | -0.573 |

**Tantalum Carbide Powder**

| | |
|---|---|
| Antimony | -0.563 |
| Cadmium | -0.529 |
| Cobalt | -0.697 |
| Iodine | -0.592 |
| Mica Muscovite Splittings | -0.566 |
| Nickel | -0.521 |
| Rutile | -0.507 |

**Appendix B**

This appendix contains the Visual Basic code that runs the PC add in developed by DORO for DNSC. It is assumed the reader understands Visual Basic and that this inclusion will explain what is happening behind the screen. Each module performs a specified task and all tasks are listed in the sequence in which they run.

```
' This program is the result of numerous contributions from a
' variety of people. I would like to Thank Major Mark Entner,
' Ms. Maureen Kinkela, and Mr. Ben Roberts. Without their
' help, suggestions, and patience this program would have
' not been possible. Major Randy Zimmerman, August 1997.



Public Measure As Integer
Public Months As Integer
Public Momentum As Integer
Public Price As Variant

' Button3_Click Macro
Sub Button3_Click() 'closes the macro calculation dialog box
    DialogSheets("Dialog1").Hide
    End
End Sub

Sub Analysis()
    Start
'   ThisWorkbook.DialogSheets("Dialog1").Show
'   Price = ThisWorkbook.DialogSheets("Dialog1").EditBoxes("Edit Box 5").Text
'   Measure = ThisWorkbook.Worksheets("Sheet1").Cells(1, 2)
'   Months = ThisWorkbook.Worksheets("Sheet1").Cells(1, 4) * 3
'   Momentum = ThisWorkbook.Worksheets("Sheet1").Cells(1, 6)
    Range(Price).Select
    Selection.Copy
'   Errorcheck (Price) 'checks the #months to graph vs #months input
    CreateNewbook 'inserts a new workbook for the evaluation
    Conversion (Price) 'converts the price values to $/LB
    Formatsheet 'formats the new sheet w/column headings
    CountRow 'performs the count function for the number of rows read in
    Equations (Price) 'inserts the equations on Evaluation sheet
    Oscillation 'sets the momentum oscillation for the eval sheet
    SOLVE_DES_MAD
    SOLVE_DES_MSE
```

```vba
'       SOLVE_VIDYA_MAD
        SOLVE_VIDYA_MSE
        Sort 'sorts the error terms in ascending order
        SelectTest 'select rows in Eval Table to graph Select Graph
        Selectspace 'selects cell A1 on all sheets
End Sub


Sub Start()
line1: ThisWorkbook.DialogSheets("Dialog1").Show
        Price = ThisWorkbook.DialogSheets("Dialog1").EditBoxes("Edit Box 5").Text
        Measure = ThisWorkbook.Worksheets("Sheet1").Cells(1, 2)
        Months = ThisWorkbook.Worksheets("Sheet1").Cells(1, 4) * 3
        Momentum = ThisWorkbook.Worksheets("Sheet1").Cells(1, 6)



'Sub Errorcheck(Price2)
    a = Range(Price).count
    If a < Months Then
    Msg = "You are attempting to graph too many months!"
        dialogstyle = vbOK + vbCritical
        Title = "Price Input Error"
            response = MsgBox(Msg, dialogstyle, Title)
            If response = vbOK Then
            GoTo line1
            End If


    End If
End Sub


Sub CreateNewbook()
    Set Newbook = Workbooks.Add 'adds new book "newbook is a variable"
    ActiveSheet.Name = "Evaluation Sheet"
    Range("A3").Select 'tells code what cell to highlight/Paste in prices
    Selection.PasteSpecial Paste:=xlValues, Operation:=xlNone, _
        SkipBlanks:=False, Transpose:=False
End Sub


Sub Conversion(Price1) 'converts prices to $/LB
    z = 3
    If Measure = 1 Then
    ElseIf Measure = 2 Then
        Do Until Cells(z, 1).Value = ""
        Cells(z, 1).Value = Cells(z, 1).Value * 2.20462262184878
        z = z + 1
        Loop
```

```
      ElseIf Measure = 3 Then
         Do Until Cells(z, 1).Value = ""
         Cells(z, 1).Value = Cells(z, 1).Value / 2240
         z = z + 1
         Loop
      ElseIf Measure = 4 Then
         Do Until Cells(z, 1).Value = ""
         Cells(z, 1).Value = Cells(z, 1).Value / 2204.62262184878
         z = z + 1
         Loop
      ElseIf Measure = 5 Then
         Do Until Cells(z, 1).Value = ""
         Cells(z, 1).Value = Cells(z, 1).Value / 2000
         z = z + 1
         Loop
      ElseIf Measure = 6 Then
         Do Until Cells(z, 1).Value = ""
         Cells(z, 1).Value = Cells(z, 1).Value / 2000
         z = z + 1
         Loop
      End If
End Sub

Sub Formatsheet()
   Range("A1").Select
   ActiveCell.FormulaR1C1 = "Price/LB"
   With Selection
      .HorizontalAlignment = xlCenter
      .VerticalAlignment = xlBottom
      .WrapText = False
      .Orientation = xlHorizontal
   End With
   Range("A2").Select
   Selection.ClearContents
   Range("B1").Select
   ActiveCell.FormulaR1C1 = "DES Forecast"
   Range("C1").Select
   ActiveCell.FormulaR1C1 = "VIDYA Forecast"
   Range("D1").Select
   ActiveCell.FormulaR1C1 = "CMO Indicater"
   Range("E1").Select
   ActiveCell.FormulaR1C1 = "Naive Forecast"
   Range("F1").Select
   ActiveCell.FormulaR1C1 = "Naive MAD"
   Range("G1").Select
```

```vba
ActiveCell.FormulaR1C1 = "Naive MSE"
Range("H1").Select
ActiveCell.FormulaR1C1 = "DES Intercept"
Range("I1").Select
ActiveCell.FormulaR1C1 = "DES Slope"
Range("J1").Select
ActiveCell.FormulaR1C1 = "DES MAD"
Range("K1").Select
ActiveCell.FormulaR1C1 = "DES MSE"
Range("L1").Select
ActiveCell.FormulaR1C1 = "STD DEV"
Range("M1").Select
ActiveCell.FormulaR1C1 = "k"
With Selection
    .HorizontalAlignment = xlCenter
    .VerticalAlignment = xlBottom
    .WrapText = False
    .Orientation = xlHorizontal
End With
Range("N1").Select
ActiveCell.FormulaR1C1 = "VIDYA MAD"
Range("O1").Select
ActiveCell.FormulaR1C1 = "VIDYA MSE"
Range("P1").Select
ActiveCell.FormulaR1C1 = "CMO Mtm Up"
Range("Q1").Select
ActiveCell.FormulaR1C1 = "CMO Mtm Dn"
Range("R1").Select
ActiveCell.FormulaR1C1 = "Su"
With Selection
    .HorizontalAlignment = xlCenter
    .VerticalAlignment = xlBottom
    .WrapText = False
    .Orientation = xlHorizontal
End With
Range("S1").Select
ActiveCell.FormulaR1C1 = "Sd"
With Selection
    .HorizontalAlignment = xlCenter
    .VerticalAlignment = xlBottom
    .WrapText = False
    .Orientation = xlHorizontal
End With
Range("T1").Select
ActiveCell.FormulaR1C1 = "ABS CMO"
```

```vba
    Range("U3").Select
    ActiveCell.FormulaR1C1 = "a"
    Range("U4").Select
    ActiveCell.FormulaR1C1 = "b"
    Range("U5").Select
    ActiveCell.FormulaR1C1 = "Ave STD DEV"
    Range("A1:AA1").Select
    Selection.EntireColumn.AutoFit
    Range("U3:U4").Select
    With Selection.Font
        .Name = "Symbol"
        .FontStyle = "Regular"
        .Size = 12
        .Strikethrough = False
        .Superscript = False
        .Subscript = False
        .OutlineFont = False
        .Shadow = False
        .Underline = xlNone
        .ColorIndex = xlAutomatic
    End With
End Sub

Sub autofill(startpt As String, formula As String)

    Range(startpt).Select
    ActiveCell.formula = formula
    Range(startpt).Select
    cnt% = ActiveSheet.Cells(6, 22).Value
    autorange$ = startpt + ":" + Left$(startpt, 1) + _
        LTrim(Str$(Val(Mid$(startpt, 2)) + cnt% + 2 - Val(Mid$(startpt, 2))))
    'MsgBox autorange$ + Str$(cnt%)
    Selection.autofill Destination:=Range(autorange$), Type:=xlFillDefault
    Range(autorange$).Select
End Sub

Sub CountRow()
    Dim i As Integer
    i = 3
    count = 0
    ActiveSheet.Cells(3, 1).Select
    Do While Cells(i, 1) > 0
        count = count + 1
        i = i + 1
    Loop
```

```vba
'   Worksheets("Evaluation Sheet").Cells(6, 22).Value = count
End Sub

Sub Equations(Price)
    Dim Price2 As Range
    Set Price2 = Range(Price).Offset(2, 0)
    Range("V3").Select
    ActiveCell.formula = "=.5" 'Start value for Alpha
    Range("V4").Select
    ActiveCell.formula = "=.5" 'Start value for Beta
    Range("f2").Select
    ActiveCell.formula = "=sum(average(f4:f1000))"
    Range("g2").Select
    ActiveCell.formula = "=sum(average(g4:g1000))"
    Range("j2").Select
    ActiveCell.formula = "=sum(average(j3:j1000))"
    Range("k2").Select
    ActiveCell.formula = "=sum(average(k3:k1000))"
    Range("n2").Select
    ActiveCell.formula = "=sum(average(n3:n1000))"
    Range("o2").Select
    ActiveCell.formula = "=sum(average(o3:o1000))"
    Range("B3").Select
    Call autofill("b3", "=H3+I3")
    Call autofill("E4", "=A3") 'Naive forecast
    Call autofill("F4", "=ABS(A4-E4)") 'Naive MAD
    Call autofill("G4", "=ABS(F4)^2") 'Naive MSE
    Call autofill("H3", "=$V$3*A3+(1-$V$3)*(H2+I2)") 'DES Intercept calculation
    Call autofill("I3", "=$V$4*(H3-H2)+(1-$V$4)*I2") 'DES Slope calculation
    Call autofill("J3", "=ABS(A3-B3)") 'DSE MAD
    Call autofill("K3", "=(J3)^2") 'DES MSE
    Call autofill("P3", "=IF(A3>A4,0,A4-A3)") 'CMO Mtm Up
    Call autofill("Q3", "=IF(A3>A4,A3-A4,0)") 'CMO Mtm Down
    Range("A2:Y1000").Select
    With Selection
        .HorizontalAlignment = xlCenter
        .VerticalAlignment = xlBottom
        .WrapText = False
        .Orientation = xlHorizontal
    End With
    Selection.NumberFormat = "0.0000"
    Selection.EntireColumn.AutoFit
End Sub

Sub Oscillation()
```

```vb
    If Momentum = 1 Then
    Range("C4").Select
    ActiveCell.formula = "=A4"
    Call autofill("C5", "=($V$3*M5)*A5+(1-$V$3*M5)*A4") 'VIDYA forecast
    Call autofill("D5", "=100*(R5-S5)/ABS(R5+S5)") 'CMO Indicater Equation
    Range("H2").Select
    ActiveCell.formula = "=index(linest($A$3:$A$5),2)" 'Y intercept
    Range("I2").Select
    ActiveCell.formula = "=index(linest($A$3:$A$5),1)" 'slope of line
    Call autofill("L5", "=STDEV(A3:A5)") '3MO STD DEV
    Call autofill("M5", "=L5/$V$5") 'K value calculation
    Call autofill("N5", "=ABS(A5-C5)") 'VIDYA MAD
    Call autofill("O5", "=(N5)^2") 'VIDYA MSE
    Call autofill("R5", "=SUM(P3:P5)") 'Su Mtm Up
    Call autofill("S5", "=SUM(Q3:Q5)") 'Su Mtm Up
    Call autofill("T5", "=ABS((R5-S5)/(R5+S5))") ' ABS CMO
    Range("V5").Select
    ActiveCell.formula = "=AVERAGE($L$5:$L$10)" 'VIDYA Constant of Ave Std Dev

    ElseIf Momentum = 2 Then
    Range("C5").Select
    ActiveCell.formula = "=A5"
    Call autofill("C6", "=($V$3*M6)*A6+(1-$V$3*M6)*A5") 'VIDYA forecast
    Call autofill("D6", "=100*(R6-S6)/ABS(R6+S6)") 'CMO Indicater Equation
    Range("H2").Select
    ActiveCell.formula = "=index(linest($A$3:$A$6),2)" 'Y intercept
    Range("I2").Select
    ActiveCell.formula = "=index(linest($A$3:$A$6),1)" 'slope of line
    Call autofill("L6", "=STDEV(A3:A6)") '4 MO STD DEV
    Call autofill("M6", "=L6/$V$5") 'K value calculation
    Call autofill("N6", "=ABS(A6-C6)") 'VIDYA MAD
    Call autofill("O6", "=(N6)^2") 'VIDYA MSE
    Call autofill("R6", "=SUM(P3:P6)") 'Su Mtm Up
    Call autofill("S6", "=SUM(Q3:Q6)") 'Su Mtm Up
    Call autofill("T6", "=ABS((R6-S6)/(R6+S6))") ' ABS CMO
    Range("V5").Select
    ActiveCell.formula = "=AVERAGE($L$6:$L$13)" 'VIDYA Constant of Ave Std Dev

    ElseIf Momentum = 3 Then
    Range("C6").Select
    ActiveCell.formula = "=A6"
    Call autofill("C7", "=($V$3*M7)*A7+(1-$V$3*M7)*A6") 'VIDYA forecast
    Call autofill("D7", "=100*(R7-S7)/ABS(R7+S7)") 'CMO Indicater Equation
    Range("H2").Select
    ActiveCell.formula = "=index(linest($A$3:$A$7),2)" 'Y intercept
```

```
Range("I2").Select
ActiveCell.formula = "=index(linest($A$3:$A$7),1)" 'slope of line
Call autofill("L7", "=STDEV(A3:A7)") '5 MO STD DEV
Call autofill("M7", "=L7/$V$5") 'K value calculation
Call autofill("N7", "=ABS(A7-C7)") 'VIDYA MAD
Call autofill("O7", "=(N7)^2") 'VIDYA MSE
Call autofill("R7", "=SUM(P3:P7)") 'Su Mtm Up
Call autofill("S7", "=SUM(Q3:Q7)") 'Su Mtm Up
Call autofill("T7", "=ABS((R7-S7)/(R7+S7))") ' ABS CMO
Range("V5").Select
ActiveCell.formula = "=AVERAGE($L$7:$L$16)" 'VIDYA Constant of Ave Std Dev

ElseIf Momentum = 4 Then
Range("C7").Select
ActiveCell.formula = "=A7"
Call autofill("C8", "=($V$3*M8)*A8+(1-$V$3*M8)*A7") 'VIDYA forecast
Call autofill("D8", "=100*(R8-S8)/ABS(R8+S8)") 'CMO Indicater Equation
Range("H2").Select
ActiveCell.formula = "=index(linest($A$3:$A$8),2)" 'Y intercept
Range("I2").Select
ActiveCell.formula = "=index(linest($A$3:$A$8),1)" 'slope of line
Call autofill("L8", "=STDEV(A3:A8)") '6 MO STD DEV
Call autofill("M8", "=L8/$V$5") 'K value calculation
Call autofill("N8", "=ABS(A8-C8)") 'VIDYA MAD
Call autofill("O8", "=(N8)^2") 'VIDYA MSE
Call autofill("R8", "=SUM(P3:P8)") 'Su Mtm Up
Call autofill("S8", "=SUM(Q3:Q8)") 'Su Mtm Up
Call autofill("T8", "=ABS((R8-S8)/(R8+S8))") ' ABS CMO
Range("V5").Select
ActiveCell.formula = "=AVERAGE($L$8:$L$19)" 'VIDYA Constant of Ave Std Dev

ElseIf Momentum = 5 Then
Range("C8").Select
ActiveCell.formula = "=A8"
Call autofill("C9", "=($V$3*M9)*A9+(1-$V$3*M9)*A8") 'VIDYA forecast
Call autofill("D9", "=100*(R9-S9)/ABS(R9+S9)") 'CMO Indicater Equation
Range("H2").Select
ActiveCell.formula = "=index(linest($A$3:$A$9),2)" 'Y intercept
Range("I2").Select
ActiveCell.formula = "=index(linest($A$3:$A$9),1)" 'slope of line
Call autofill("L9", "=STDEV(A3:A9)") '7 MO STD DEV
Call autofill("M9", "=L9/$V$5") 'K value calculation
Call autofill("N9", "=ABS(A9-C9)") 'VIDYA MAD
Call autofill("O9", "=(N9)^2") 'VIDYA MSE
Call autofill("R9", "=SUM(P3:P9)") 'Su Mtm Up
```

```vba
    Call autofill("S9", "=SUM(Q3:Q9)") 'Su Mtm Up
    Call autofill("T9", "=ABS((R9-S9)/(R9+S9))") ' ABS CMO
    Range("V5").Select
    ActiveCell.formula = "=AVERAGE($L$9:$L$22)" 'VIDYA Constant of Ave Std Dev

    ElseIf Momentum = 6 Then
    Range("C9").Select
    ActiveCell.formula = "=A9"
    Call autofill("C10", "=($V$3*M10)*A10+(1-$V$3*M10)*A9") 'VIDYA forecast
    Call autofill("D10", "=100*(R10-S10)/ABS(R10+S10)") 'CMO Indicater Equation
    Range("H2").Select
    ActiveCell.formula = "=index(linest($A$3:$A$10),2)" 'Y intercept
    Range("I2").Select
    ActiveCell.formula = "=index(linest($A$3:$A$10),1)" 'slope of line
    Call autofill("L10", "=STDEV(A3:A10)") '8 MO STD DEV
    Call autofill("M10", "=L10/$V$5") 'K value calculation
    Call autofill("N10", "=ABS(A10-C10)") 'VIDYA MAD
    Call autofill("O10", "=(N10)^2") 'VIDYA MSE
    Call autofill("R10", "=SUM(P3:P10)") 'Su Mtm Up
    Call autofill("S10", "=SUM(Q3:Q10)") 'Su Mtm Up
    Call autofill("T10", "=ABS((R10-S10)/(R10+S10))") ' ABS CMO
    Range("V5").Select
    ActiveCell.formula = "=AVERAGE($L$10:$L$25)" 'VIDYA Constant of Ave Std
Dev

    ElseIf Momentum = 7 Then
    Range("C10").Select
    ActiveCell.formula = "=A10"
    Call autofill("C11", "=($V$3*M11)*A11+(1-$V$3*M11)*A10") 'VIDYA forecast
    Call autofill("D11", "=100*(R11-S11)/ABS(R11+S11)") 'CMO Indicater Equation
    Range("H2").Select
    ActiveCell.formula = "=index(linest($A$3:$A$11),2)" 'Y intercept
    Range("I2").Select
    ActiveCell.formula = "=index(linest($A$3:$A$11),1)" 'slope of line
    Call autofill("L11", "=STDEV(A3:A11)") '9 MO STD DEV
    Call autofill("M11", "=L11/$V$5") 'K value calculation
    Call autofill("N11", "=ABS(A11-C11)") 'VIDYA MAD
    Call autofill("O11", "=(N11)^2") 'VIDYA MSE
    Call autofill("R11", "=SUM(P3:P11)") 'Su Mtm Up
    Call autofill("S11", "=SUM(Q3:Q11)") 'Su Mtm Up
    Call autofill("T11", "=ABS((R11-S11)/(R11+S11))") ' ABS CMO
    Range("V5").Select
    ActiveCell.formula = "=AVERAGE($L$11:$L$28)" 'VIDYA Constant of Ave Std
Dev
```

```
ElseIf Momentum = 8 Then
    Range("C11").Select
    ActiveCell.formula = "=A11"
    Call autofill("C12", "=($V$3*M12)*A12+(1-$V$3*M12)*A11") 'VIDYA forecast
    Call autofill("D12", "=100*(R12-S12)/ABS(R12+S12)") 'CMO Indicater Equation
    Range("H2").Select
    ActiveCell.formula = "=index(linest($A$3:$A$12),2)" 'Y intercept
    Range("I2").Select
    ActiveCell.formula = "=index(linest($A$3:$A$12),1)" 'slope of line
    Call autofill("L12", "=STDEV(A3:A12)") '10 MO STD DEV
    Call autofill("M12", "=L12/$V$5") 'K value calculation
    Call autofill("N12", "=ABS(A12-C12)") 'VIDYA MAD
    Call autofill("O12", "=(N12)^2") 'VIDYA MSE
    Call autofill("R12", "=SUM(P3:P12)") 'Su Mtm Up
    Call autofill("S12", "=SUM(Q3:Q12)") 'Su Mtm Up
    Call autofill("T12", "=ABS((R12-S12)/(R12+S12))") ' ABS CMO
    Range("V5").Select
    ActiveCell.formula = "=AVERAGE($L$12:$L$31)" 'VIDYA Constant of Ave Std
Dev

    ElseIf Momentum = 9 Then
    Range("C12").Select
    ActiveCell.formula = "=A12"
    Call autofill("C13", "=($V$3*M13)*A13+(1-$V$3*M13)*A12") 'VIDYA forecast
    Call autofill("D13", "=100*(R13-S13)/ABS(R13+S13)") 'CMO Indicater Equation
    Range("H2").Select
    ActiveCell.formula = "=index(linest($A$3:$A$13),2)" 'Y intercept
    Range("I2").Select
    ActiveCell.formula = "=index(linest($A$3:$A$13),1)" 'slope of line
    Call autofill("L13", "=STDEV(A3:A13)") '11 MO STD DEV
    Call autofill("M13", "=L13/$V$5") 'K value calculation
    Call autofill("N13", "=ABS(A13-C13)") 'VIDYA MAD
    Call autofill("O13", "=(N13)^2") 'VIDYA MSE
    Call autofill("R13", "=SUM(P3:P13)") 'Su Mtm Up
    Call autofill("S13", "=SUM(Q3:Q13)") 'Su Mtm Up
    Call autofill("T13", "=ABS((R13-S13)/(R13+S13))") ' ABS CMO
    Range("V5").Select
    ActiveCell.formula = "=AVERAGE($L$13:$L$34)" 'VIDYA Constant of Ave Std
Dev

    ElseIf Momentum = 10 Then
        Range("C13").Select
        ActiveCell.formula = "=A13"
        Call autofill("C14", "=($V$3*M14)*A14+(1-$V$3*M14)*A13") 'VIDYA forecast
        Call autofill("D14", "=100*(R14-S14)/ABS(R14+S14)") 'CMO Indicater Equation
```

```vba
    Range("H2").Select
    ActiveCell.formula = "=index(linest($A$3:$A$14),2)" 'Y intercept
    Range("I2").Select
    ActiveCell.formula = "=index(linest($A$3:$A$14),1)" 'slope of line
    Call autofill("L14", "=STDEV(A3:A14)") '12 MO STD DEV
    Call autofill("M14", "=L14/$V$5") 'K value calculation
    Call autofill("N14", "=ABS(A14-C14)") 'VIDYA MAD
    Call autofill("O14", "=(N14)^2") 'VIDYA MSE
    Call autofill("R14", "=SUM(P3:P14)") 'Su Mtm Up
    Call autofill("S14", "=SUM(Q3:Q14)") 'Su Mtm Up
    Call autofill("T14", "=ABS((R14-S14)/(R14+S14))") ' ABS CMO
    Range("V5").Select
    ActiveCell.formula = "=AVERAGE($L$14:$L$37)" 'VIDYA Constant of Ave Std
Dev

  ElseIf Momentum = 11 Then
    Range("C14").Select
    ActiveCell.formula = "=A14"
    Call autofill("C15", "=($V$3*M15)*A15+(1-$V$3*M15)*A14") 'VIDYA forecast
    Call autofill("D15", "=100*(R15-S15)/ABS(R15+S15)") 'CMO Indicater Equation
    Range("H2").Select
    ActiveCell.formula = "=index(linest($A$3:$A$15),2)" 'Y intercept
    Range("I2").Select
    ActiveCell.formula = "=index(linest($A$3:$A$15),1)" 'slope of line
    Call autofill("L15", "=STDEV(A3:A15)") '13 MO STD DEV
    Call autofill("M15", "=L15/$V$5") 'K value calculation
    Call autofill("N15", "=ABS(A15-C15)") 'VIDYA MAD
    Call autofill("O15", "=(N15)^2") 'VIDYA MSE
    Call autofill("R15", "=SUM(P3:P15)") 'Su Mtm Up
    Call autofill("S15", "=SUM(Q3:Q15)") 'Su Mtm Up
    Call autofill("T15", "=ABS((R15-S15)/(R15+S15))") ' ABS CMO
    Range("V5").Select
    ActiveCell.formula = "=AVERAGE($L$15:$L$40)" 'VIDYA Constant of Ave Std
Dev

  ElseIf Momentum = 12 Then
    Range("C15").Select
    ActiveCell.formula = "=A15"
    Call autofill("C16", "=($V$3*M16)*A16+(1-$V$3*M16)*A15") 'VIDYA forecast
    Call autofill("D16", "=100*(R16-S16)/ABS(R16+S16)") 'CMO Indicater Equation
    Range("H2").Select
    ActiveCell.formula = "=index(linest($A$3:$A$16),2)" 'Y intercept
    Range("I2").Select
    ActiveCell.formula = "=index(linest($A$3:$A$16),1)" 'slope of line
    Call autofill("L16", "=STDEV(A3:A16)") '14 MO STD DEV
```

```
        Call autofill("M16", "=L16/$V$5") 'K value calculation
        Call autofill("N16", "=ABS(A16-C16)") 'VIDYA MAD
        Call autofill("O16", "=(N16)^2") 'VIDYA MSE
        Call autofill("R16", "=SUM(P3:P16)") 'Su Mtm Up
        Call autofill("S16", "=SUM(Q3:Q16)") 'Su Mtm Up
        Call autofill("T16", "=ABS((R16-S16)/(R16+S16))") ' ABS CMO
        Range("V5").Select
        ActiveCell.formula = "=AVERAGE($L$16:$L$43)" 'VIDYA Constant of Ave Std
Dev

    ElseIf Momentum = 13 Then
        Range("C16").Select
        ActiveCell.formula = "=A16"
        Call autofill("C17", "=($V$3*M17)*A17+(1-$V$3*M17)*A16") 'VIDYA forecast
        Call autofill("D17", "=100*(R17-S17)/ABS(R17+S17)") 'CMO Indicater Equation
        Range("H2").Select
        ActiveCell.formula = "=index(linest($A$3:$A$17),2)" 'Y intercept
        Range("I2").Select
        ActiveCell.formula = "=index(linest($A$3:$A$17),1)" 'slope of line
        Call autofill("L17", "=STDEV(A3:A17)") '15 MO STD DEV
        Call autofill("M17", "=L17/$V$5") 'K value calculation
        Call autofill("N17", "=ABS(A17-C17)") 'VIDYA MAD
        Call autofill("O17", "=(N17)^2") 'VIDYA MSE
        Call autofill("R17", "=SUM(P3:P17)") 'Su Mtm Up
        Call autofill("S17", "=SUM(Q3:Q17)") 'Su Mtm Up
        Call autofill("T17", "=ABS((R17-S17)/(R17+S17))") ' ABS CMO
        Range("V5").Select
        ActiveCell.formula = "=AVERAGE($L$17:$L$46)" 'VIDYA Constant of Ave Std
Dev

    ElseIf Momentum = 14 Then
        Range("C17").Select
        ActiveCell.formula = "=A17"
        Call autofill("C18", "=($V$3*M18)*A18+(1-$V$3*M18)*A17") 'VIDYA forecast
        Call autofill("D18", "=100*(R18-S18)/ABS(R18+S18)") 'CMO Indicater Equation
        Range("H2").Select
        ActiveCell.formula = "=index(linest($A$3:$A$18),2)" 'Y intercept
        Range("I2").Select
        ActiveCell.formula = "=index(linest($A$3:$A$18),1)" 'slope of line
        Call autofill("L18", "=STDEV(A3:A18)") '16 MO STD DEV
        Call autofill("M18", "=L18/$V$5") 'K value calculation
        Call autofill("N18", "=ABS(A18-C18)") 'VIDYA MAD
        Call autofill("O18", "=(N18)^2") 'VIDYA MSE
        Call autofill("R18", "=SUM(P3:P18)") 'Su Mtm Up
        Call autofill("S18", "=SUM(Q3:Q18)") 'Su Mtm Up
```

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        Call autofill("T18", "=ABS((R18-S18)/(R18+S18))") ' ABS CMO
        Range("V5").Select
        ActiveCell.formula = "=AVERAGE($L$18:$L$49)" 'VIDYA Constant of Ave Std
Dev

    ElseIf Momentum = 15 Then
        Range("C18").Select
        ActiveCell.formula = "=A18"
        Call autofill("C19", "=($V$3*M19)*A19+(1-$V$3*M19)*A18") 'VIDYA forecast
        Call autofill("D19", "=100*(R19-S19)/ABS(R19+S19)") 'CMO Indicater Equation
        Range("H2").Select
        ActiveCell.formula = "=index(linest($A$3:$A$19),2)" 'Y intercept
        Range("I2").Select
        ActiveCell.formula = "=index(linest($A$3:$A$19),1)" 'slope of line
        Call autofill("L19", "=STDEV(A3:A19)") '17 MO STD DEV
        Call autofill("M19", "=L19/$V$5") 'K value calculation
        Call autofill("N19", "=ABS(A19-C19)") 'VIDYA MAD
        Call autofill("O19", "=(N19)^2") 'VIDYA MSE
        Call autofill("R19", "=SUM(P3:P19)") 'Su Mtm Up
        Call autofill("S19", "=SUM(Q3:Q19)") 'Su Mtm Up
        Call autofill("T19", "=ABS((R19-S19)/(R19+S19))") ' ABS CMO
        Range("V5").Select
        ActiveCell.formula = "=AVERAGE($L$19:$L$52)" 'VIDYA Constant of Ave Std
Dev

    Else
    Momentum = 16
        Range("C19").Select
        ActiveCell.formula = "=A19"
        Call autofill("C20", "=($V$3*M20)*A20+(1-$V$3*M20)*A19") 'VIDYA forecast
        Call autofill("D20", "=100*(R20-S20)/ABS(R20+S20)") 'CMO Indicater Equation
        Range("H2").Select
        ActiveCell.formula = "=index(linest($A$3:$A$20),2)" 'Y intercept
        Range("I2").Select
        ActiveCell.formula = "=index(linest($A$3:$A$20),1)" 'slope of line
        Call autofill("L20", "=STDEV(A3:A20)") '18 MO STD DEV
        Call autofill("M20", "=L20/$V$5") 'K value calculation
        Call autofill("N20", "=ABS(A20-C20)") 'VIDYA MAD
        Call autofill("O20", "=(N20)^2") 'VIDYA MSE
        Call autofill("R20", "=SUM(P3:P20)") 'Su Mtm Up
        Call autofill("S20", "=SUM(Q3:Q20)") 'Su Mtm Up
        Call autofill("T20", "=ABS((R20-S20)/(R20+S20))") ' ABS CMO
        Range("V5").Select
        ActiveCell.formula = "=AVERAGE($L$20:$L$55)" 'VIDYA Constant of Ave Std
Dev
```

```
        End If
    Range("A2:Y1000").Select
    With Selection
        .HorizontalAlignment = xlCenter
        .VerticalAlignment = xlBottom
        .WrapText = False
        .Orientation = xlHorizontal
    End With
    Selection.NumberFormat = "0.0000"
    Selection.EntireColumn.AutoFit
End Sub


' SOLVE_DES_MAD Macro
' Solves for the optimal alpha and beta values for DES MAD
'
'

Sub SOLVE_DES_MAD()

    Sheets("Evaluation Sheet").Select
    Range("v3").Select
    i = 1
    sheet = "Evaluation Sheet"
    minsse = Worksheets(sheet).Cells(2, 10)
    alpha = Worksheets(sheet).Cells(3, 22)
    beta = Worksheets(sheet).Cells(4, 22)
    While Worksheets(sheet).Cells(3, 22) >= 0.05
      While Worksheets(sheet).Cells(4, 22) >= 0.05
       If Worksheets(sheet).Cells(2, 10) < minsse Then
         minsse = Worksheets(sheet).Cells(2, 10)
         alpha = Worksheets(sheet).Cells(3, 22)
         beta = Worksheets(sheet).Cells(4, 22)
       End If
      ' Worksheets("Sheet3").Cells(i, 1) = Worksheets(sheet).Cells(3, 22)
      ' Worksheets("Sheet3").Cells(i, 2) = Worksheets(sheet).Cells(4, 22)
      'Worksheets("Sheet3").Cells(i, 3) = Worksheets(sheet).Cells(2, 10)
       ' i = i + 1
      Worksheets(sheet).Cells(4, 22) = _
       Worksheets(sheet).Cells(4, 22) - 0.05
      Wend
      Worksheets(sheet).Cells(4, 22) = 0.5
      Worksheets(sheet).Cells(3, 22) = _
        Worksheets(sheet).Cells(3, 22) - 0.05
    Wend
    Worksheets(sheet).Cells(3, 22) = alpha
    Worksheets(sheet).Cells(4, 22) = beta
```

```
Sheets("Sheet2").Select
Sheets("Sheet2").Name = "Comparison Table"
Range("A2").Select
ActiveCell.Value = 1
Range("A3").Select
ActiveCell.Value = 2
Range("A4").Select
ActiveCell.Value = 3
Range("A5").Select
ActiveCell.Value = 4
Range("A6").Select
ActiveCell.Value = 5
Range("A7").Select
ActiveCell.Value = 6
Range("C1").Select
ActiveCell.formula = "Error"

Sheets("Evaluation Sheet").Select
Range("F2").Select
Selection.Copy
Sheets("Comparison Table").Select
Range("C2").Select
Selection.PasteSpecial Paste:=xlValues, Operation:=xlNone, _
    SkipBlanks:=False, Transpose:=False
Selection.NumberFormat = "0.0000"
Range("B2").Select
ActiveCell.formula = "Naive MAD"
Sheets("Evaluation Sheet").Select
Range("G2").Select
Selection.Copy
Sheets("Comparison Table").Select
Range("C3").Select
Selection.PasteSpecial Paste:=xlValues, Operation:=xlNone, _
    SkipBlanks:=False, Transpose:=False
Selection.NumberFormat = "0.0000"
Range("B3").Select
ActiveCell.formula = "Naive MSE"

Sheets("Evaluation Sheet").Select
Range("J2").Select
Selection.Copy
Sheets("Comparison Table").Select
Range("C4").Select
Selection.PasteSpecial Paste:=xlValues, Operation:=xlNone, _
```

```
        SkipBlanks:=False, Transpose:=False
    Selection.NumberFormat = "0.0000"
    Range("B4").Select
    ActiveCell.formula = "DES MAD"

    Sheets("Evaluation Sheet").Select
    Range("V3").Select
    Selection.Copy
    Sheets("Comparison Table").Select
    Range("D4").Select
    Selection.PasteSpecial Paste:=xlValues, Operation:=xlNone, _
        SkipBlanks:=False, Transpose:=False
    Selection.NumberFormat = "0.0000"
    Range("D1").Select
    ActiveCell.formula = "ALPHA"

    Sheets("Evaluation Sheet").Select
    Range("V4").Select
    Selection.Copy
    Sheets("Comparison Table").Select
    Range("E4").Select
    Selection.PasteSpecial Paste:=xlValues, Operation:=xlNone, _
        SkipBlanks:=False, Transpose:=False
    Selection.NumberFormat = "0.0000"
    Range("E1").Select
    ActiveCell.formula = "BETA"

    Sheets("Evaluation Sheet").Select
    Range("V3").Select
    ActiveCell.formula = "=.5" 'Start value for Alpha
    Range("V4").Select
    ActiveCell.formula = "=.5" 'Start value for Beta
End Sub

' SOLVE_DES_MSE Macro
' Solves for the optimal alpha and beta values for DES MSE by minimizing the overall
MSE
'
'

Sub SOLVE_DES_MSE()
    Sheets("Evaluation Sheet").Select
    sheet = "Evaluation Sheet"
    minsse = Worksheets(sheet).Cells(2, 11)
    alpha = Worksheets(sheet).Cells(3, 22)
    beta = Worksheets(sheet).Cells(4, 22)
```

```vba
While Worksheets(sheet).Cells(3, 22) >= 0.05
  While Worksheets(sheet).Cells(4, 22) >= 0.05
  If Worksheets(sheet).Cells(2, 11) < minsse Then
    minsse = Worksheets(sheet).Cells(2, 11)
    alpha = Worksheets(sheet).Cells(3, 22)
    beta = Worksheets(sheet).Cells(4, 22)
  End If
  Worksheets(sheet).Cells(4, 22) = _
    Worksheets(sheet).Cells(4, 22) - 0.05
  Wend
  Worksheets(sheet).Cells(4, 22) = 0.5
  Worksheets(sheet).Cells(3, 22) = _
    Worksheets(sheet).Cells(3, 22) - 0.05
Wend
Worksheets(sheet).Cells(3, 22) = alpha
Worksheets(sheet).Cells(4, 22) = beta

Sheets("Evaluation Sheet").Select
Range("K2").Select
Selection.Copy
Sheets("Comparison Table").Select
Range("C5").Select
Selection.PasteSpecial Paste:=xlValues, Operation:=xlNone, _
  SkipBlanks:=False, Transpose:=False
Selection.NumberFormat = "0.0000"
Range("B5").Select
ActiveCell.formula = "DES MSE"

Sheets("Evaluation Sheet").Select
Range("V3").Select
Selection.Copy
Sheets("Comparison Table").Select
Range("D5").Select
Selection.PasteSpecial Paste:=xlValues, Operation:=xlNone, _
  SkipBlanks:=False, Transpose:=False
Selection.NumberFormat = "0.0000"

Sheets("Evaluation Sheet").Select
Range("V4").Select
Selection.Copy
Sheets("Comparison Table").Select
Range("E5").Select
Selection.PasteSpecial Paste:=xlValues, Operation:=xlNone, _
  SkipBlanks:=False, Transpose:=False
Selection.NumberFormat = "0.0000"
```

```vba
    Sheets("Evaluation Sheet").Select
    Range("V3").Select
    ActiveCell.formula = "=.5" 'Start value for Alpha
    Range("V4").Select
    ActiveCell.formula = "=.5" 'Start value for Beta
End Sub


' SOLVE_VIDYA_MAD Macro
' Solves for the optimal alpha value for VIDYA MAD
'
Sub SOLVE_VIDYA_MAD()
    Sheets("Evaluation Sheet").Select
    sheet = "Evaluation Sheet"
    minsse = Worksheets(sheet).Cells(2, 14)
    alpha = Worksheets(sheet).Cells(3, 22)
    While Worksheets(sheet).Cells(3, 22) >= 0.05
        If Worksheets(sheet).Cells(2, 14) < minsse Then
            minsse = Worksheets(sheet).Cells(2, 14)
            alpha = Worksheets(sheet).Cells(3, 22)
        End If
        Worksheets(sheet).Cells(3, 22) = _
            Worksheets(sheet).Cells(3, 22) - 0.01
    Wend
    Worksheets(sheet).Cells(3, 22) = alpha

    Sheets("Evaluation Sheet").Select
    Range("N2").Select
    Selection.Copy
    Sheets("Comparison Table").Select
    Range("C6").Select
    Selection.PasteSpecial Paste:=xlValues, Operation:=xlNone, _
        SkipBlanks:=False, Transpose:=False
    Selection.NumberFormat = "0.0000"
    Range("B6").Select
    ActiveCell.formula = "VIDYA MAD"

    Sheets("Evaluation Sheet").Select
    Range("V3").Select
    Selection.Copy
    Sheets("Comparison Table").Select
    Range("D6").Select
    Selection.PasteSpecial Paste:=xlValues, Operation:=xlNone, _
        SkipBlanks:=False, Transpose:=False
    Selection.NumberFormat = "0.0000"
```

```
   Range("E6").Select
   ActiveCell.formula = "N/A"

   Sheets("Evaluation Sheet").Select
   Range("V3").Select
   ActiveCell.formula = "=.5" 'Start value for Alpha
   Range("V4").Select
   ActiveCell.formula = "=.5" 'Start value for Beta

End Sub

' SOLVE_VIDYA_MSE Macro
' Solves for the optimal alpha and beta values for VIDYA MSE
'
Sub SOLVE_VIDYA_MSE()
   Sheets("Evaluation Sheet").Select
   Sheets("Evaluation Sheet").Select
   sheet = "Evaluation Sheet"
   minsse = Worksheets(sheet).Cells(2, 15)
   alpha = Worksheets(sheet).Cells(3, 22)
   While Worksheets(sheet).Cells(3, 22) >= 0.05
     If Worksheets(sheet).Cells(2, 15) < minsse Then
       minsse = Worksheets(sheet).Cells(2, 15)
       alpha = Worksheets(sheet).Cells(3, 22)
     End If
     Worksheets(sheet).Cells(3, 22) = _
       Worksheets(sheet).Cells(3, 22) - 0.01
   Wend
   Worksheets(sheet).Cells(3, 22) = alpha

   Sheets("Evaluation Sheet").Select
   Range("O2").Select
   Selection.Copy
   Sheets("Comparison Table").Select
   Range("C7").Select
   Selection.PasteSpecial Paste:=xlValues, Operation:=xlNone, _
     SkipBlanks:=False, Transpose:=False
   Selection.NumberFormat = "0.0000"
   Range("B7").Select
   ActiveCell.formula = "VIDYA MSE"

   Sheets("Evaluation Sheet").Select
   Range("V3").Select
   Selection.Copy
   Sheets("Comparison Table").Select
```

```vba
   Range("D7").Select
   Selection.PasteSpecial Paste:=xlValues, Operation:=xlNone, _
      SkipBlanks:=False, Transpose:=False
   Selection.NumberFormat = "0.0000"
   Range("E7").Select
   ActiveCell.formula = "N/A"
   Range("A1:E7").Select
   Selection.EntireColumn.AutoFit

   Sheets("Evaluation Sheet").Select
   Range("V3").Select
   ActiveCell.formula = "=.5" 'Start value for Alpha
   Range("V4").Select
   ActiveCell.formula = "=.5" 'Start value for Beta

End Sub

Sub Sort()
   Sheets("Comparison Table").Select
   Range("A1:E7").Select
   Selection.Sort _
      Key1:=Range("C2"), Order1:=xlAscending, _
      Key2:=Range("D2"), Order2:=xlAscending, _
      Key3:=Range("E2"), Order3:=xlAscending, _
      Header:=xlYes, OrderCustom:=1, MatchCase:=False, Orientation:= _
         xlTopToBottom
End Sub

Sub SelectTest()
   Sheets("Evaluation Sheet").Cells(3, 22).Value _
      = Sheets("Comparison Table").Cells(2, 4).Value
   Sheets("Evaluation Sheet").Cells(4, 22).Value _
      = Sheets("Comparison Table").Cells(2, 5).Value
   Sheets("Evaluation Sheet").Select 'selection for the price values
   i = 3
   Do Until Cells(i, 1).Value = ""
         i = i + 1
   Loop
   Range(Cells(i - Months, 1), Cells(i - 1, 1)).Select
   Selection.Copy
   Sheets("Sheet3").Select
   Cells(2, 2).Select
   Selection.PasteSpecial Paste:=xlValues, Operation:=xlNone, _
      SkipBlanks:=False, Transpose:=False
   Selection.NumberFormat = "$#,##0.00"
```

```vba
Range("B1").Select
ActiveCell.FormulaR1C1 = "Price"
Range("A1").Select
ActiveCell.FormulaR1C1 = "CMO"
Sheets("Evaluation Sheet").Select 'selection for CMO values
i = Momentum + 4
Do Until Cells(i, 4).Value = ""
      i = i + 1
Loop
Range(Cells(i - Months, 4), Cells(i - 1, 4)).Select
Selection.Copy
Sheets("Sheet3").Select
Cells(2, 1).Select
Selection.PasteSpecial Paste:=xlValues, Operation:=xlNone, _
   SkipBlanks:=False, Transpose:=False
Selection.NumberFormat = "0.0000"

Sheets("Comparison Table").Select
  If Cells(2, 1).Value <= 2 Then
    Msg = "Naive Forecast has minimum error!"
    dialogstyle = vbOK + vbCritical
    Title = "Forecast Instability Error"
      response = MsgBox(Msg, dialogstyle, Title)
      If response = vbOK Then
      GoTo Endit
      End If
      MsgBox Msg
Endit:

    ElseIf Cells(2, 1).Value <= 4 Then
      Sheets("Evaluation Sheet").Select 'selection for the DES values
      i = 3
      Do Until Cells(i, 2).Value = "" '"" indicates find null space
          i = i + 1
      Loop
      Range(Cells(i - Months, 2), Cells(i - 1, 2)).Select
      Selection.Copy
      Sheets("Sheet3").Select
      Cells(2, 3).Select
      Selection.PasteSpecial Paste:=xlValues, Operation:=xlNone, _
        SkipBlanks:=False, Transpose:=False
      Selection.NumberFormat = "$#,##0.00"
      Range("C1").Select
      ActiveCell.FormulaR1C1 = "DES"
```

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```vba
Else
    Sheets("Evaluation Sheet").Select 'selection for VIDYA values
    i = Momentum + 4
    Do Until Cells(i, 3).Value = ""
        i = i + 1
    Loop
    Range(Cells(i - Months, 3), Cells(i - 1, 3)).Select
    Selection.Copy
    Sheets("Sheet3").Select
    Cells(2, 3).Select
    Selection.PasteSpecial Paste:=xlValues, Operation:=xlNone, _
        SkipBlanks:=False, Transpose:=False
    Selection.NumberFormat = "$#,##0.00"
    Range("C1").Select
    ActiveCell.FormulaR1C1 = "VIDYA"


End If


Sheets("Sheet3").Select
Range(Cells(1, 1), Cells(Months + 1, 3)).Select
Charts.Add
If Months = 3 Then
ActiveChart.ChartWizard Source:=Sheets("Sheet3").Range("A1:C4"), _
    Gallery:=xlCombination, Format:=2, PlotBy:= _
    xlColumns, CategoryLabels:=0, SeriesLabels:=1, HasLegend:=1, _
    Title:="", CategoryTitle:="Months", ValueTitle:="Momentum", _
    ExtraTitle:="Price"


ElseIf Months = 6 Then
ActiveChart.ChartWizard Source:=Sheets("Sheet3").Range("A1:C7"), _
    Gallery:=xlCombination, Format:=2, PlotBy:= _
    xlColumns, CategoryLabels:=0, SeriesLabels:=1, HasLegend:=1, _
    Title:="", CategoryTitle:="Months", ValueTitle:="Momentum", _
    ExtraTitle:="Price"


ElseIf Months = 9 Then
ActiveChart.ChartWizard Source:=Sheets("Sheet3").Range("A1:C10"), _
    Gallery:=xlCombination, Format:=2, PlotBy:= _
    xlColumns, CategoryLabels:=0, SeriesLabels:=1, HasLegend:=1, _
    Title:="", CategoryTitle:="Months", ValueTitle:="Momentum", _
    ExtraTitle:="Price"


ElseIf Months = 12 Then
ActiveChart.ChartWizard Source:=Sheets("Sheet3").Range("A1:C13"), _
    Gallery:=xlCombination, Format:=2, PlotBy:= _
```

```
                xlColumns, CategoryLabels:=0, SeriesLabels:=1, HasLegend:=1, _
                Title:="", CategoryTitle:="Months", ValueTitle:="Momentum", _
                ExtraTitle:="Price"

        ElseIf Months = 15 Then
        ActiveChart.ChartWizard Source:=Sheets("Sheet3").Range("A1:C16"), _
                Gallery:=xlCombination, Format:=2, PlotBy:= _
                xlColumns, CategoryLabels:=0, SeriesLabels:=1, HasLegend:=1, _
                Title:="", CategoryTitle:="Months", ValueTitle:="Momentum", _
                ExtraTitle:="Price"

        ElseIf Months = 18 Then
        ActiveChart.ChartWizard Source:=Sheets("Sheet3").Range("A1:C19"), _
                Gallery:=xlCombination, Format:=2, PlotBy:= _
                xlColumns, CategoryLabels:=0, SeriesLabels:=1, HasLegend:=1, _
                Title:="", CategoryTitle:="Months", ValueTitle:="Momentum", _
                ExtraTitle:="Price"

        ElseIf Months = 21 Then
        ActiveChart.ChartWizard Source:=Sheets("Sheet3").Range("A1:C22"), _
                Gallery:=xlCombination, Format:=2, PlotBy:= _
                xlColumns, CategoryLabels:=0, SeriesLabels:=1, HasLegend:=1, _
                Title:="", CategoryTitle:="Months", ValueTitle:="Momentum", _
                ExtraTitle:="Price"

        ElseIf Months = 24 Then
        ActiveChart.ChartWizard Source:=Sheets("Sheet3").Range("A1:C25"), _
                Gallery:=xlCombination, Format:=2, PlotBy:= _
                xlColumns, CategoryLabels:=0, SeriesLabels:=1, HasLegend:=1, _
                Title:="", CategoryTitle:="Months", ValueTitle:="Momentum", _
                ExtraTitle:="Price"

    End If
    ActiveChart.SeriesCollection(2).Select
    ActiveChart.SeriesCollection(2).AxisGroup = 2
    ActiveChart.ChartGroups(2).Type = xlLine
    ActiveChart.Axes(xlValue).Select
    With ActiveChart.Axes(xlValue)
        .MinimumScale = -100
        .MaximumScale = 100
        .MinorUnit = 5
        .MajorUnit = 10
        .Crosses = xlAutomatic
        .ReversePlotOrder = False
        .ScaleType = False
```

```
End With
ActiveChart.Axes(xlValue).Select
Selection.TickLabels.NumberFormat = "0"
With ActiveChart.Axes(xlValue, xlSecondary)
    .MinimumScale = 0
    .MajorUnit = 0.02
End With
ActiveChart.Axes(xlCategory).Select
ActiveChart.SeriesCollection(1).Select
With Selection.Border
    .Weight = xlThin
    .LineStyle = xlAutomatic
End With
Selection.InvertIfNegative = False
With Selection.Interior
    .ColorIndex = 24
    .Pattern = xlSolid
End With
ActiveChart.SeriesCollection(2).Select
With Selection.Border
    .ColorIndex = 5
    .Weight = xlThin
    .LineStyle = xlContinuous
End With
With Selection
    .MarkerBackgroundColorIndex = 5
    .MarkerForegroundColorIndex = 5
    .MarkerStyle = xlTriangle
    .Smooth = False
End With
ActiveChart.SeriesCollection(3).Select
With Selection.Border
    .ColorIndex = 5
    .Weight = xlThin
    .LineStyle = xlContinuous
End With
With Selection
    .MarkerBackgroundColorIndex = 5
    .MarkerForegroundColorIndex = 5
    .MarkerStyle = xlTriangle
    .Smooth = False
End With
ActiveChart.SeriesCollection(2).Select
With Selection.Border
    .ColorIndex = 7
```

```vba
        .Weight = xlThin
        .LineStyle = xlContinuous
    End With
    With Selection
        .MarkerBackgroundColorIndex = 7
        .MarkerForegroundColorIndex = 7
        .MarkerStyle = xlTriangle
        .Smooth = False
    End With
    ActiveChart.PlotArea.Select
    With Selection.Border
        .ColorIndex = 16
        .Weight = xlThin
        .LineStyle = xlContinuous
    End With
    Selection.Interior.ColorIndex = xlNone
    ActiveChart.Deselect
End Sub

Sub Selectspace()
    Sheets("Evaluation Sheet").Select
    Range("A1").Select
    Sheets("Comparison Table").Select
    Range("A1:A7").Select
    Selection.Delete Shift:=xlToLeft
    Range("A1:D7").Select
    Selection.EntireColumn.AutoFit
    Range("A1").Select
    Sheets("Sheet3").Select
    Range("A1").Select
    Sheets("Chart1").Select
End Sub
```

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This report documents a study of commodity bid offers made to the Defense National Stockpile Center (DNSC). The purpose of the study was to provide DNSC with better information about potential changes in market commodity prices. This report provides the project findings of the new PC based price forecasting model, "market basket" decision support package, and "optimal" price methodology.

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